MEASURING THE EFFECTIVENESS OF COMPUTING SERVICES

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This thesis reports research that was carried out to develop a management tool for measuring the effectiveness of computing services. Effectiveness was considered in terms of the degree to which services met users' needs, and measured by the degree of satisfaction expressed by users concerning those services.

The tool which was developed comprised a questionnaire survey of the user population, the construction and analysis of a data base of responses, interviews with users, and acquisition of knowledge of the local computing environment.

Adequate development of the tool was achieved by carrying out two investigations of the services provided by the University of Canterbury Computer Centre. The major factors underlying the users' satisfaction responses were exposed, and their overall levels of satisfaction with these factors were used to measure the effectiveness of the service. The influence of various user and use characteristics on satisfaction was then examined. Both investigations revealed the importance of the human face of the service. Effectiveness was seen to depend on the provision of a technically adequate, yet convenient and friendly service.

The results of the investigations showed that worthwhile information for a concerned computer centre management can be obtained relatively easily using the tool.

CHAPTER ONE

INTRODUCTION

The development of computer technology is at a stage where the discipline is still emerging and the technical possibilities are being explored by computer professionals. At the same time, the new technology is being employed in a wide range of applications by users who are not computer professionals.

It has been a common observation of such applications that wider use and acceptance of computers depends not only on the development of greater computing power, but also on the delivery of that potential in useful and effective ways. Since the technology is being used to assist complex human activity, many factors affect its usefulness. At the present time, the success of these applications depends on an understanding of the role of these factors in the use of computing.

This research deals with the provision of computing services by the computer centres of universities and similar institutions. Generally, these computer centres handle the majority of the academic and administrative workloads, and provide both a technical capacity and support services. The adequacy of these services is judged by users on an individual basis. The user will evaluate and base future expectations on how well the computer performs for him, and how well his needs, as perceived by him, are being met. On the other hand, a computer centre, while being responsive to the needs of its users, is bound by its internal structure and organizational context, and must operate within financial and technical constraints. The term *effectiveness* is loosely associated with the degree of success of such an operation.

In this research, we were interested in assessing the effectiveness of computing services as viewed by the users of those services. Our aim

was to develop a suitable criterion for effectiveness and a tool that could be used by computer centre management to measure this. Thus we were concerned with the nature of the interaction that exists between the users and the services. The wider issue of evaluating the social effectiveness of the use of computers was not tackled here.

The problem of assessing effectiveness was dealt with by adopting the user satisfaction approach, and drawing from previous work, particularly that of McKaskill (1978), that has used it in other computing environments. The essence of this approach was that effectiveness was defined as the extent to which the users' computing needs were met. This, in turn, was measured by the degree of satisfaction expressed by the users.

Integral to the investigation of effectiveness, considered in these terms, was the testing of hypotheses concerning the influence of the following factors on user satisfaction:

(a) User characteristics - personal and situational factors such as status, work type, skills and experience.

(b) Use characteristics - mode, medium, use of the system and support services.

The study of these factors required the application of established social science methods with existing knowledge of man-computer interaction. The tool which was developed comprised a questionnaire survey, construction and statistical analysis of a data base of questionnaire responses, interviews with users, and acquisition of knowledge of the local computing environment.

Development of this tool required two investigations of the services provided by the University of Canterbury Computer Centre. Initial research and part of the first study were completed by Mary Chen as a project towards her B.Sc. Honours course at the University of Canterbury (Chen, 1978). She formulated a questionnaire, carried out

a pilot study, then collected data from 187 users and subjected these data to preliminary statistical analysis. This work showed that meaningful associations could be identified between user satisfaction and characteristics of the user and usage.

The first task of the current project was to carry out further statistical analysis of the Chen data base. A number of components underlying user satisfaction were identified, and then explanations were sought for the variations in the levels of satisfaction expressed by users. From the range of user characteristics that had been surveyed, a number were found to be significantly associated with the user satisfaction components.

In order to confirm these results and to identify other factors that might affect user satisfaction, twenty volunteer users were selected on the basis of the patterns of their questionnaire responses and interviewed. This process provided practical explanations of why these users felt the way they did about the service.

On the basis of this feedback, the original questionnaire was redesigned and the second investigation was carried out in 1980. Survey data were collected from 192 users, and 22 were interviewed. Data analysis possibilities were explored more fully than had been done with the data from the first investigation, and development of a suitable analysis technique was completed.

Two papers summarising the methodology and results were published during 1981 (Good, Power and Chen, 1981a; 1981b). The tool was used to study the effectiveness of computing services provided by the Computer Centre of the University of Otago. This work was carried out by Chrystine Burnside as a project towards her B.Sc. Honours course at the University of Canterbury (Burnside, 1981).

The remainder of the thesis is organized in four chapters as follows:

Chapter Two contains a review of the literature on man-computer interaction, studies of effectiveness, and the measurement of user satisfaction.

In Chapter Three, methodology of the management tool is given. This covers the behavioural model upon which this research is based, the means used to measure effectiveness, and the major components of the tool.

The results of the two investigations that were carried out at Canterbury are described and compared in Chapter Four.

In Chapter Five, we report our conclusions regarding the usefulness of the tool which was developed.

CHAPTER TWO

REVIEW OF THE LITERATURE

2.1 BACKGROUND

The use of computers in our society has been established and is becoming wide-spread. The development of computer technology appears to be following a pattern which Firnberg (1973) suggests is true of all emerging technologies:

Stage 1 Specialised usage by a few experts, while the new technology generally encounters resistance and disbelief.

Stage 2 The "horseless carriage" phase in which the new technology is used to replace previous technologies at the same tasks.

Stage 3 A new language and discipline emerge which permit the use of the technology in new ways for new purposes.

Stage 4 The wider implications of the use of the technology are understood and it becomes a tool for non-specialist users.

Stage 5 The technology is fully developed, and its use is routine and integrated into society.

Firnberg's own work concerned the use of information systems as a management tool. He saw the common use of computer technology to be somewhere between stages 2 and 3 at the time of writing.

With the continuing development of computer technology, particularly as it approaches the fourth stage identified by Firnberg, there has been a growth of interest in the more human-oriented issues. Early work done in the field of man-computer interaction (as reviewed by Davis, 1966)

concerned the widening range of applications of computer systems and the rapid technological development that allowed this. Effort was directed toward the development of interactive terminal devices, "more natural" programming languages, and computer-based problem-solving techniques. The comparison of time-sharing versus batch processing has been studied extensively (Gold, 1969; Hansen, 1976; Sackman, 1970; Smith, 1967).

In these and other studies, the typical approach taken was to measure various levels of user performance under experimental conditions. The importance of the role of human factors was recognised, but there was a considerable lack in the methods for studying human behaviour. Sackman described the situation thus:

> "...narrow technical considerations and immediate cost constraints dominated computer technology, in large part at the expense of human ease, convenience and social effectiveness; computer system professionals were not equipped or trained to measure and test human performance in computer-aided systems." (*op.cit.*, p14)

Recent work of interest has involved non-experimental studies of users in their organizational context. Since the majority of studies have dealt with users in specialised environments, and the range of interaction involved depends on the specific environment, we shall introduce three categories of use, and some of the research that has been done in these areas.

2.1.1 Professional Programmers

Users in the first category, whom we shall call "professional programmers", write computer programs essentially for other people. These programmers typically work in software houses, in DP departments of large organizations, and in consultative organizations. These users have been the subject of investigation by, for instance, Weinberg (1971). In his highly anecdotal book, he advocates the "egoless programming" approach to the organization of programming activity, so that the

individual programmer's effectiveness is maximised. An alternative approach, using the "chief programming team", has been advocated by Mills (1973). The results of some studies of professional programmers have been reviewed by Boswell (1981). A view of "the typical programmer" emerged that has implications for the management of programmers and for the clients of the data processing profession. For instance, programmers were found to have low social responsibility and a low need for social interaction.

2.1.2 Naive Users

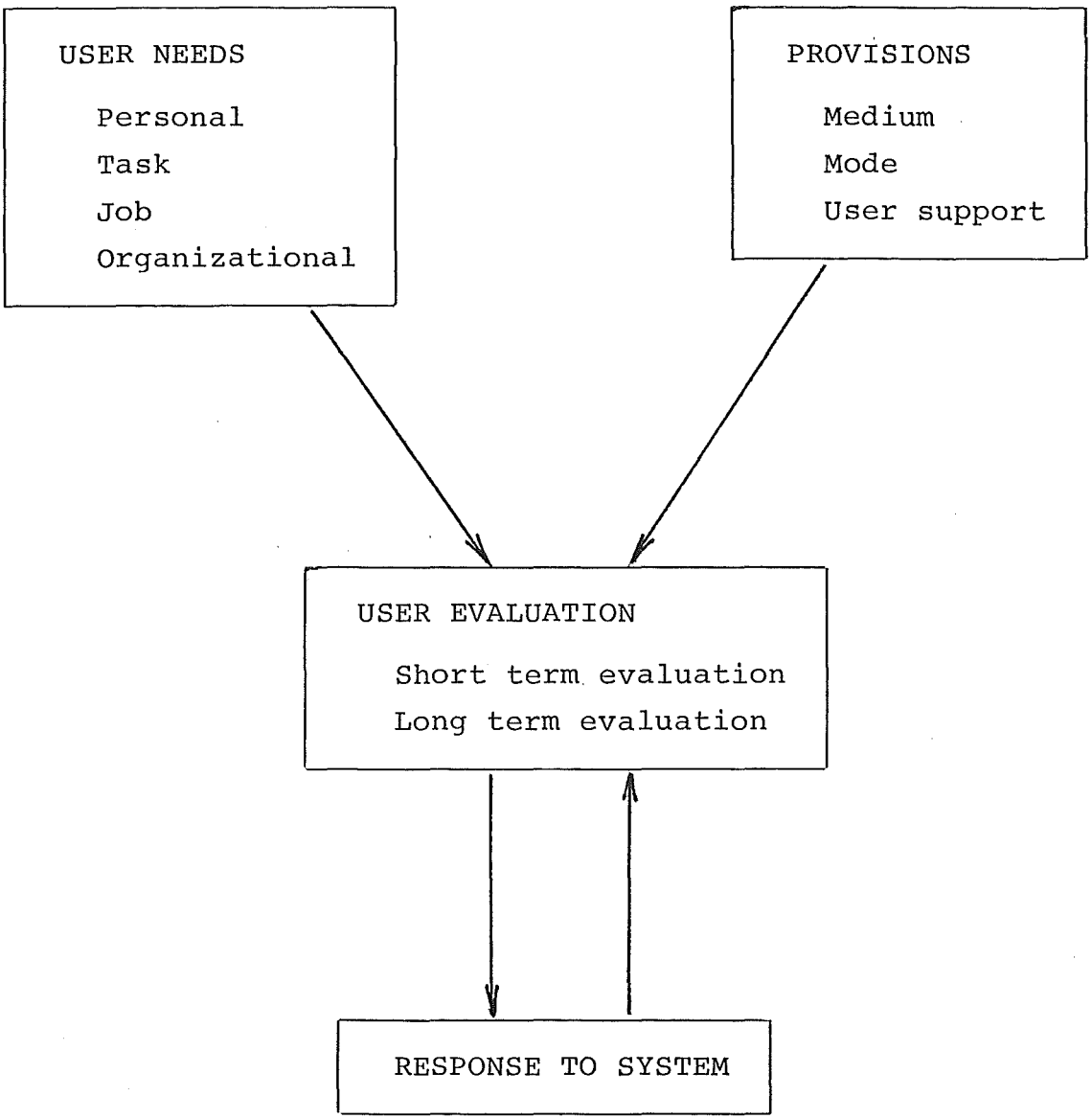
In the second category of users are the clerical and managerial staff for whom programs are written and information services provided. These persons were dubbed "naive users" by Eason *et al.* (1974) in their study of the users of commerical systems. Clerical users are typically involved in routine procedures to prepare and enter data, and to handle output in standard clerical tasks, such as record-keeping, accounting and invoicing, for which the computer fills a data processing function. Managerial users are characterised by their use of the computer as a source of information for decision making. They are the end-users of computer-based management information systems and exercise far more discretion in their use of the computer than clerical users do.

The study of Eason *et al.* included both naive users and amateur programmers (discussed subsequently). A general behavioural model was developed to describe the influences on these users' responses to the system. This model is presented in summary form in Figure 1.

The model shows that a wide range of factors were considered to influence use of a computer system. These factors were classified as either user needs or the provisions made by the system to meet those needs. Eason *et al.* described several sources of the needs felt by the user: the tasks for which the computer is used, the user's job, and the organization within which the user works. In addition, a wide

Figure 1

Variables Determining the User's Response



Source: Adapted from Eason *et al.*, 1974: Figure 11, p31.

range of personal needs, such as ergonomic considerations and psychological differences, were considered to influence use of a computer system.

The range of services studied by Eason *et al.* allowed the user a great many possible forms of interaction. The services and hence the forms of interaction were categorized according to the characteristics *medium, mode* and *user support*. Medium referred to the means of communication between the user and the computer system; i.e. whether this was direct, via interactive terminals, or indirect using batch processing via card decks and printout. Mode concerned the software facilities employed by the user for his task. User support, comprising documentary support and human support, concerned the source of information and assistance made available to the user.

In the course of using the computing service, and in order to determine his response, the user will make evaluations of two kinds, according to the model. The first is a series of specific short term assessments, for example on matters of suitability and strategy. A user makes such assessments only if there is not already an acceptable pattern of behaviour for carrying out his/her task. The second kind is a long term evaluation of the impact on the user's work, satisfaction, etc. This evaluation involves the steady accumulation over time of information from the user's experiences, and the user's assessment of indirect consequences of use of the computer. One source of material for attitude information is the attitude of other users. Eason *et al.* suggest that these general attitudes provide the frame of reference within which the individual approaches the system.

The model was tested by way of a questionnaire survey of the users of 26 commercial systems in the United Kingdom. Four indices (task fit, ease of use, user support, and indirect consequences) were constructed for summarising questionnaire responses. Various job types and forms

of interaction were identified by the survey; furthermore, the response of different types of users and their differing requirements were assessed.

2.1.3 Amateur Programmers

The present study considers computer users who form the general user population of computer centres at universities and other educational, scientific and engineering organizations. These users are specialists in some technical or academic field. Although these specialists, together with clerical and managerial users, were referred to as "naive users" by Eason *et al.*, we reserve use of that term to the latter two groups, and refer to specialists as "amateur programmers".

Amateur programmers come from a wide range of disciplines, yet they differ significantly from users in the professional programmer and naive user categories. Characteristically, amateur programmers write programs for their own use, being both producer and consumer. Their use of the computer is seen as a means to an end, whether that be analysis of experimental data, an increased knowledge of computing itself, or another of the great number of current applications.

Amateur programmers' patterns of utilization of computing resources have been studied in order to understand the nature of the work load that they generate (Hunt *et al.*, 1971; Haralambopoulos and Nagy, 1977). Experimental studies have been conducted with undergraduate users to determine learning rates (Jutila and Baram, 1971) and for comparisons of performance under time-sharing and batch processing conditions (Sackman, 1970).

Guidelines have been presented for the effective use of computers in higher education, and for measuring needs and resources for instructional computing (Mosmann, 1973; 1977). Co-ordination of state-wide computing systems has also been discussed (Mosmann, 1974). Universities have been studied as part of a formal organizational model

(Gross, 1968) and university computing has been viewed as a political process (Wiste, 1976).

The use of official advisory services has been studied in detail by Alty and Coombs (1978; 1980). Their papers report surveys of the use, organization, and user perceptions of advisory services in four university computer centres in the United Kingdom. They found that the advisory services were highly valued as an instant source of guidance and correct and pertinent information. On the other hand, users claimed that they did not always understand the advice given. Such misunderstanding was found to be mediated by expertise, and expert users were found to be much more satisfied with the service than inexpert users. In another paper (Coombs and Alty, 1980), they reported direct investigations of the interactions between users and advisors. The authors came to the following conclusions about the nature and function of the advisory service:

> "(a) the advisory service is a problem solving institution; it works well for both expert and inexpert users at the problem solving level;
>
> (b) there is room for far greater flexibility in advisory response, particularly for the inexpert user;
>
> (c) there is a need to train advisors to recognize deficiencies in user knowledge and to supply appropriate and succinct explanations;
>
> (d) there is a need to raise the status of the advisory function." (Coombs and Alty, 1980, p428)

The study report of Eason *et al.* (1974) provides much information about the use of computers by amateur programmers in the commercial environment. Amateur programmers were found to be using computers to produce detailed and sophisticated solutions to complex problems, many of which could not have been tackled by manual methods. Some used the computer only indirectly, engaging professional programmers to carry out their computing tasks. The type of close contact required for this arrangement was difficult to achieve in many companies where the

specialist and the computing department were both organizationally and physically remote.

Most amateur programmers were required to develop considerable computing expertise, and this had a large impact on their jobs. Many were found to become increasingly reluctant to change a particular computer-based solution once it had been developed. They preferred instead to modify the problem, and there was a tendency towards tackling only problems for which ready-made tools were available. Some specialists became highly skilled at programming and worked, in part, either by themselves or in conjunction with professional programmers to produce sophisticated packages that could be used by other specialists.

In general, specialists were found to be more highly involved with the computer than managerial staff, and more aware of computing and able to exercise more discretion in their use of computing than managerial or clerical users. It was concluded that:

> "Specialists require complex software and suites of programs which they can tailor to their needs without being diverted from their main task. They may be prepared to learn programming and complex operating procedures but will probably only spend a small proportion of their time actually using the system." (*op.cit.*, p178)

2.2 STUDIES OF EFFECTIVENESS

We have shown that amateur programmers use computers in sophisticated and complex ways. When considering the provision of computing services for these users, Mosmann (1973, p64) claimed that an effective computing organization should provide the means for reaching the following complex and sometimes conflicting objectives:

(a) Satisfaction of the users' real needs

(b) User recognition of value and scarcity in computing

(c) Supplier efficiency

(d) Encouragement of useful growth

(e) Control of stability and protection of the user

(f) Encouragement of careful and skillful management

(g) Evolution of goals and policy

(h) Provision of a focus for responsibility and authority.

The need to evaluate the effectiveness of a computer centre stems from the complexity of these objectives; so also does the difficulty of measuring effectiveness.

From the body of literature relating to the measurement of the effectiveness of organizations in general, it appears that effectiveness has been used as a label for a number of related concepts, and that it has been studied from many viewpoints. We now review the known approaches to measuring the effectiveness of organizations providing computing services.

2.2.1 Formal Review

A formal review of operations and practices has been used by the management of computer centres in universities as a means of improving service effectiveness. The computing service audit procedure that was adopted by the Inter University Committee on Computing in the United Kingdom was originally proposed by Scott (1974). The procedure was

later adapted by Williams (1979) for use in the United States by the Special Interest Group on University Computing Centers; (SIGUCC is a member organization of the Association for Computing Machinery).

The IUCC computing service audit procedure and the SIGUCC peer review procedure are fundamentally similar. A small team of experienced computer professionals is selected from outside the institution under review. They are given access to information and are free to interview staff. They are required to present a written report on the review to the director of the computer centre; further circulation of the report is at the discretion of the director.

Some discussion on the use of this approach is provided by Wells (1974) and Law (1974). Robinson (1980) describes the integration of the peer review approach into the computer centre's planning process. These three publications attest the benefits of the approach: a rapid, comprehensive review providing both formal and informal criticism, and suggestions for improvements.

A different kind of review has recently been undertaken in New Zealand by an investigative team established by the Audit Office. Their objective was:

> "To report to Parliament on the current level of use of computers within the public sector and the extent to which management is efficiently using and properly controlling these and related sources." (Shailes, 1980, p76)

The team surveyed 521 organizations in order to determine the extent and cost of computing and the applications and staffing of installations in the public sector. In addition, they interviewed staff at 100 organizations and undertook a formal review of the management of 38 of the larger installations. An evaluation table was developed to provide a consistent means of assessment; installations were rated according to the standards of each of the desirable management practices listed in the table.

Using these methods, the team identified a large number of common problem areas and made many strong recommendations aimed to improve the existing systems. Their final report (*op. cit.*) also included a set of guidelines for the management of computers and the evaluation table as a checklist for managers.

It is clear that the specific evaluation and recommendations for each installation could be of considerable benefit if communicated to the management concerned. It is not explicit in the report that this was done.

2.2.2 User Perfomance

The effectiveness of computing services has been considered in terms of the performance of users with respect to personal or organizational goals.

Lucas (1975) studied the use of an information system by sales personnel, and attempted to trace the contribution it made to organizational performance. He developed a descriptive model of the relationships between use of the system, performance, decision style, attitudes, system quality, and situational and personal factors. The model was tested by the collection and analysis of questionnaire data and existing records. Performance was measured by the financial value of sales attributed to each sales person over a one year period.

The results of this study showed only weak associations between performance and use of the information system. However, several personal, situational and decision style variables were found to affect the use of information systems. Furthermore, the findings suggested the existence of multiple roles for an information system. Lucas argued the case for greater flexibility in the design of information systems, so that these human factors could be better catered for.

The use of financial return as a measure of performance appears most suitable in the situation studied by Lucas: maximum return is a highly important goal for individual users of the information system and the organization. However, this measure of performance does not reflect non-financial or long-term benefits.

In discussion on the use and evaluation of information systems, McKaskill (1978) suggested that the information produced has potential meaning only in the decision making process, and that its effectiveness should be evaluated in this context. He observed that the use of computer output and other sources of information in this process is highly complex, and in fact the decision maker may not even be able to describe how he arrives at his decision. It did not seem possible to attribute the benefit gained by use of the information system to the use of particular output or services. He concluded that the use of this approach to measure the effectiveness of an information system was a near impossible task.

2.2.3 Achievement of Organizational Goals

In this approach, effectiveness is defined in terms of the degree to which an organization realizes its goals (Etzioni, 1964). In order to measure the effectiveness of an organization, its goals must be identified, and its achievement of those goals must be measured.

Major criticism of this approach centres on the problem of goal identification. Offical goals have been distinguished from operative goals by Perrow (1961), and there are two corresponding approaches to the problem. The prescribed goal approach is characterized by the study of official goals, whereas in the derived goal approach, the intentions and activities of the major decision makers are examined and in this way the operative or actual goals are derived. The latter approach has been used for developing an effectiveness index for use in managing

university computer centres (Varanelli, 1978).

In the study reported by Varanelli, four measures were constructed for evaluating effectiveness. Two measures were based on the perceptions of the user of how well their computer centre was achieving certain goals, and the other two measures were based on centre performance characteristics provided by the chief administrator of the computer centre. The relationship between the "perceived" and "operational" measures was explored, and these measures were used for a comparative study of the computer centres of ten universities in the United States.

Varanelli did not report the exact procedure that was used to identify computer centre goals. He provided only a general procedure based on the guides for the goal approach listed by Price (1972a). Neither did he report the organizational goals that were identified; hence it is not possible to see what goal achievement was measured.

The method used by Varanelli to measure goal achievement stemmed from the study of community general hospitals by Georgopoulos and Mann (1962). In this study, a number of determinants of hospital effectiveness were measured by asking hospital staff to rate the quality of patient care provided. The data were collected from hospital staff since they were considered generally competent to evaluate the adequacy of patient care. By contrast, an approach based on patient satisfaction was dismissed because patients were considered unable to provide an acceptable evaluation (because of their medical and psychological condition and lack of medical knowledge). Also, the goals and expectations of patients and those providing the care were often at variance, and the researchers' interest was in the provision of "good" care, and not necessarily in the provision of patient-satisfactory care.

It was suggested by Price (1972b) that the non-comparative measure of patient care developed by Georgopoulos and Mann could be adapted for general use in studies of effectiveness. However, the use of this method

by Varanelli differed in one respect: the organization's achievement of its goals was assessed by individuals (users) outside this organization (the computer centre) and not by those within it (centre staff). This departure from the original method has an unfortunate consequence: certain goals that could be identified by the researcher as organizational goals may not be shared by the outside individuals and it may be unrealistic to expect a valid assessment from them.

Varanelli states (but does not demonstrate) that the technique is able to highlight areas of poor computer centre performance. Similarly, it is claimed that the derived goal approach provides a means for measuring effectiveness in many situations where users are vying for the use of scarce recourses. However, it is not clear how Varanelli's method takes account of their varying computing needs and possibly different goals.

2.2.4 User Satisfaction

With this approach, effectiveness is considered in terms of the degree of satisfaction expressed by users concerning the computing products and services that they use. User satisfaction has been used to measure effectiveness by Powers and Dickson (1973), McKaskill (1978) and van der Hart (1979) among others.

Powers and Dickson studied the effectiveness of management information system projects. Four criteria of project success were selected: completion time, financial cost, user satisfaction and impact of the project. The user satisfaction component was described as the attitude of user managers relative to how well their information needs were being satisfied.

The relationships between these measures of project success and possible predictive factors were tested using a simple bivariate correlation technique. Unfortunately, Powers and Dickson did not

describe in detail how they measured user satisfaction.

The study by McKaskill (1978) concerned user satisfaction with the total information system or data processing operation. A total of 138 managers of functional departments in 21 manufacturing companies were questionned concerning their use of their companies' data processing services. Follow-up interviews were held with 48 of the user managers and the data processing manager of each installation.

McKaskill proposed a model of the factors expected to influence system effectiveness, and these were categorized as organizational context factors, systems context factors, management choice factors and personal factors. User managers were asked to rate the level of benefits achieved through use of the system, the level of information support for decision making, their level of satisfaction with specific operations, and their attitudes to various aspects of computer systems. A multiple-question approach was used to survey each of these areas, and a mathematical procedure was used to detect underlying user satisfaction components. Four such components or factors were identified and subsequently used as measures of user satisfaction. In decreasing order of importance these were:

(a) INTERACTION, the quality of the immediate interaction between users and data processing staff.

(b) SUPPORT, the short term operational and decision making support received by the users.

(c) IMPACT, the perceived level of benefits received by the organization from its computer investment.

(d) DESIGN, the quality of the systems work performed by the data processing staff.

The relationships between these user satisfaction measures and the factors expected to influence effectiveness were tested and some surprising results were obtained. For instance, the satisfaction of

users with the DESIGN factor was positively associated with the amount of experience that the DP managers had in functional (or user) departments. By comparison, the amount of experience the DP manager had in data processing was negatively associated with all four satisfaction factors. McKaskill reported that:

> "In the least effective companies it was generally found that poor communication existed between the two areas and lack of functional knowledge and understanding by the DP manager may be a fundamental cause of this." (*op. cit.* p227)

Follow-up interviews with users tended to explain and confirm the results of the analysis.

The work by van der Hart (1979) involved a marketing approach to measuring the performance of a university computer centre. Two organizational objectives were identified for the centre under study: a promotional function and an operational task. Achievement of the promotional function was not measured. The centre's performance of its operational task was measured by the calculation of a performance index for each of 27 service elements. Index values were derived from user satisfaction and importance ratings collected using a postal survey. Index values for the 27 service elements were compared and used to draw attention to unsatisfactory services.

Cross-tabulations with user characteristics were performed to identify groups of dissatisfied users. The marketing approach suggested that where the target group (the user population) could be segmented according to their different needs, these market segments could be treated separately. Rough segmentation on the basis of user involvement was made by categorizing users according to the number of jobs they ran per year. Very frequent users were considered to deserve every attention, because they accounted for a large part of the work load and were thought to act as channels for distribution and communication between the centre and other users.

Conclusions from this segmentation and the priorities indicated by the index values could be used in the formulation of an overall marketing plan for the centre.

2.2.5 Summary and Conclusions

The literature reveals a number of approaches that have been made to the formal study of the effectiveness of computing services, or of the organizational effectiveness of computer centres. We now summarize the fundamentals of these approaches and the conclusions reached concerning their suitability for this research.

(a) Formal review: effectiveness is largely undefined; the organization's activities are investigated by a team of outside experts. The review procedures use predominantly non-quantitative methods, and as such provide no firm basis for the comparison of the effectiveness of different computer centres, or of the same centre under changes of time and circumstance. Instead, they use a normative approach, relying on the experience and good (but largely subjective) judgement of the investigators. However, the peer review procedure has been used successfully with university computer centres, and could possibly incorporate a quantitative measure of effectiveness.

(b) User performance: effectiveness is defined in terms of the level of performance or benefit attributable to the use of the services, and measured according to some individual or organizational indication of success. The use of performance as a measure of effectiveness does not appear currently feasible, because of the lack of established and widely-applicable performance measures.

(c) Achievement of organizational goals: measurement of effectiveness requires the identification of organizational goals, and the measurement of the organization's achievement of these goals. Although this approach has been used with university computer centres,

insufficient details are supplied in the paper by Varanelli (1978) to allow replication of the study. There appear to be considerable difficulties in the process of goal identification and no firm basis for using the assessments of outside individuals concerning the organization's achievement of its goals to measure effectiveness.

(d) User satisfaction: effectiveness is defined by the degree of satisfaction expressed by users concerning the services. User satisfaction has been employed by McKaskill (1978) as a measure of effectiveness for management information systems in the commercial environment with interesting results. This approach appears suitable for a computer centre whose *raison d'être* is to meet the needs of its users.

2.3 USER SATISFACTION

The concept of satisfaction, particularly with reference to job satisfaction, has been a major subject of study for psychologists. There is general agreement that satisfaction is an attitude; an individual's attitude toward something is characterised by the direction (either positive or negative) and intensity of the feeling about it.

2.3.1 Measuring the Satisfaction of Computer Users

Research into the measurement of job satisfaction has provided some guidance for the measurement of computer user satisfaction. The principal contribution of the study of job satisfaction conducted by Wanous and Lawler (1972) was to affirm the validity of measuring a subject's satisfaction with a number of facets of the same experience.

This multiple facet approach was used in the study of computer user satisfaction by Pearson and Bailey (1980). They defined user satisfaction as:

> "...the sum of feelings or affective responses to distinguishable factors of the computer-based information products and services that are provided within the organization." (*op. cit.* p59)

The users under study were middle managers in commercial organizations. A formal procedure was developed for identifying the factors relevant to their use of computing services, and thirty-nine factors were selected. Users were asked to rate their feelings of satisfaction by completing bipolar adjective scales for each factor. For example, concerning the format of output, they were asked to mark their responses on scales constructed from the following adjective pairs: good-bad, simple-complex, readable-unreadable, useful-useless. Four such adjective pairs were provided per factor. In addition, the pairs satisfactory-unsatisfactory and important-unimportant were always included. Seven-point scales were used, and integer or linear scores

were assigned to the response categories. Raw factor scores were calculated as the average of the first four scores; the fifth score was used as a direct measure of satisfaction, and the sixth as a weight indicating importance.

These data were used to calculate two different total scores for each individual. The unweighted total was calculated as the sum of the raw scores, whereas for the weighted total, the raw scores were weighted according to the importance scores and then summed. These constructs correspond to the direct facet satisfaction measure and the weighted direct facet satisfaction measure studied by Wanous and Lawler (1972, Equations 1 and 2). Weighted and unweighted total scores were found to correspond very closely: the Pearson product-moment correlation coefficient for these two measures was 0.9968. This extremely high correlation indicated that the use of a weighting function did little to increase the information conveyed by the less complex unweighted score. The importance that respondents attached to the factors was found to be reflected in the intensity of their other responses. This result accords with the conclusion of Wanous and Lawler, that weighting by importance is unnecessary (*op. cit.* p104).

The arguments presented by Pearson and Bailey concerning the reliability and validity of their construct are consequently based on the unweighted scores. One such argument reported the comparison of raw factor scores (based on the first four scales) and direct factor satisfaction scores (from the fifth scale). The correlation between these two scores was calculated for each factor; these correlations were generally very high: they ranged from 0.75 to 0.97, with an average value of 0.91. This generally close correspondence was used to affirm the predictive validity of the raw factor scores. However, this correspondence, and the use of the direct facet measure as the basis of comparison in this study and in the Wanous and Lawler study,

indicate the suitability of the direct measure on its own for evaluating satisfaction.

2.3.2 Satisfaction Data and Effectiveness Measurement

In the studies by McKaskill (1978) and van der Hart (1979), user satisfaction data were collected for the purposes of evaluating the effectiveness of organizations providing computing services. These studies were reviewed briefly in Section 2.2.4; however, they are of further interest in the light of the work on satisfaction measurement reviewed above, and because of the ways in which the satisfaction data were used.

Both studies employed the multiple facet approach and, for each satisfaction topic, response categories labelled with adjectives. McKaskill used three groups of questions regarding the satisfaction of user managers with their information systems and data processing departments. Within each group of questions, response categories were labelled and scored consistently. Five-point scales were used to measure both the direction (positive or negative) and intensity of the user's feelings or attitudes toward each topic.

By contrast, there was some variation in the labelling of response categories used by van der Hart. He was specifically interested in dissatisfaction, and this was reflected in the categories and scoring. For example, a question regarding waiting times employed the following scale:

SATISFACTION CATEGORY	SYMBOL	ATTENTION SCORE
Much too long	W^{--}	2
Rather long	W^{-}	1
Acceptable	W	0
Hardly occurring	W^{+}	0

Users were also asked to rate the importance of each service element on a three point scale:

IMPORTANCE CATEGORY	SYMBOL	IMPORTANCE SCORE
Very important	B^+	2
Important	B	1
Slightly important	B^-	0

The users' satisfaction and importance data for each service element were combined according to the following formula:

$$\text{Index} = 100 \times (NB/N + 2 \times NB^+/N) \times (NW^-/N + 2 \times NW^{--}/N),$$

where NB, NB^+, NW^- and NW^{--} were the numbers of responses in the corresponding categories, and N was the total number of respondents.

These performance indexes, devised by van der Hart, lack a clearly-defined meaning. Since index values were calculated from different measurement scales, the validity of comparing them is doubtful. The use of importance data with suitably-constructed satisfaction measurement scales has been shown to be unnecessary.

Although dissatisfaction data may be useful for certain purposes, truncation of the satisfaction response scale has a major drawback: it prohibits exploration of the dynamics of user satisfaction. This appears essential since satisfaction is being used to evaluate effectiveness.

The collection of satisfaction data by McKaskill closely resembled the direct facet satisfaction measure (Wanous and Lawley, 1972, Equation 2). However, factor analysis was used in an attempt to expose underlying patterns in the data. This statistical method is commonly used for its data reduction capability: correlations between variables are examined and a small number of common determinants or factors are

extracted. The influence of these factors on the observed variables is expressed mathematically as a matrix of factor loadings; that is, a loading for each factor on each variable.

The four major factors that were identified by McKaskill, and the variables most highly associated with them, are shown in Table 1. McKaskill also used factor analysis to generate scores that indicated an individual's satisfaction with each factor. In this way the theoretical constructs (the factors labelled Interaction, Support, Impact and Design) were represented by four newly-created satisfaction variables. These new variables were used as measures of effectiveness. McKaskill went on to examine the influence on effectiveness of specific management practices and other factors in the user-service interaction. The four factors were found to describe different aspects of effectiveness, and various predictor variables were found to be associated with each factor.

Table 1

Structure of the factors exposed by McKaskill

FACTOR	LABEL AND DESCRIPTION	COMPONENTS	FACTOR LOADING
ONE	INTERACTION Quality of Interaction between users and DP staff	Advised of delays on computer operations	.69
		Quality of data preparation work	.63
		Advised of delays in data preparation	.80
		Willingness of data preparation staff to change arrangements	.64
		Kept informed on changes	
TWO	SUPPORT Co-operativeness and willingness of DP staff	Interdepartmental relationships in joint activities	.67
		Ease of contacting DP staff	.75
		Response to requests	.60
		Willingness of DP to alter arrangements	.63
THREE	IMPACT Impact of Computer Investment	Operating Costs	.50
		Employee productivity	.59
		Quality of customer service	.67
		Production efficiency	.61
FOUR	DESIGN Quality of the design system	Quality of systems maintenance work	.64
		Opinion of how good the computer systems are	.75
		Opinion on level of benefits received	.66

SOURCE: McKaskill, 1978: Table 6.2, p119

2.4 SUMMARY

Studies of man-computer interaction have generally considered users in specific environments. We have identified three broad categories of users: professional programmers, naive users and amateur programmers.

Our interest in effectiveness was to develop a concept suitable for computer centres that provide services to amateur programmers, and a means for measuring it. No adequate work of this nature appeared to have been done before.

The concept of effectiveness chosen was the degree of satisfaction which users express about the service. Analysis of data concerning the users, the services they use and their satisfaction with the differing facets of the service, provided the means for measuring this concept of effectiveness. This did not measure effectiveness in terms of the goals of the university or of society; neither was it a complete study of the effectiveness of a computer centre in terms of Etzioni's definition of effectiveness. Many goals could be identified in the formal charter of the organization and in the actions and intentions of its members. However, this informal one was chosen as being the most important, likely to be widely accepted, and worthy of further research.

Techniques to analyse effectiveness in the information systems context had been developed by McKaskill. These were based on the widely-accepted direct facet measure of satisfaction, but employed a complex analysis in order to expose underlying satisfaction factors. It appeared that this method could be developed for use with the amateur programmers who use the computing services provided at universities and similar institutions.

The behavioural model developed by Eason *et al.* appeared suitable for providing a framework for investigating the interaction between amateur programmers and the computing services they use, and the influence of these factors on user satisfaction.

CHAPTER THREE

METHODOLOGY

The purpose of this research was to develop a management tool for measuring the effectiveness, in terms of user satisfaction, of a computing service centre. The tool was to be economical and easy to use.

A questionnaire survey was used to collect data about a large sample of users, their use of the services and their satisfaction with them. The effectiveness of the service was rated in terms of the overall satisfaction of these users. The questionnaire data were also used to explain the variations in the users' levels of satisfaction by reference to their own characteristics and the ways in which they used the services. The distribution of satisfaction responses enabled users with particular and defined patterns of feeling about the services to be selected and interviewed, if they were willing. The interviews were designed to yield detailed information about the service as viewed through the eyes of its users and to help to explain why they felt as they did.

3.1 THE BEHAVIOURAL MODEL

Our approach to investigating effectiveness, that of measuring and analysing user satisfaction, required a formal basis for the explanation of the behaviour of the human being as a computer user. Such a behavioural model had to incorporate the possible effects of the nature and quality of a computer system and support services on the user and the user's satisfaction with them.

For these purposes, we began with the model developed by Eason *et al.* (1974), which was reviewed in Section 2.1.2. We made certain modifications which were in keeping with our interests in user satisfaction, amateur programmers, and the university environment.

The product of these modifications was the behavioural model which is summarised in Figure 2. This model defined the scope of the research and guided our investigation, particularly at the stage of determining questionnaire content. The major components of the model and our approach to studying them are discussed in the sections which follow.

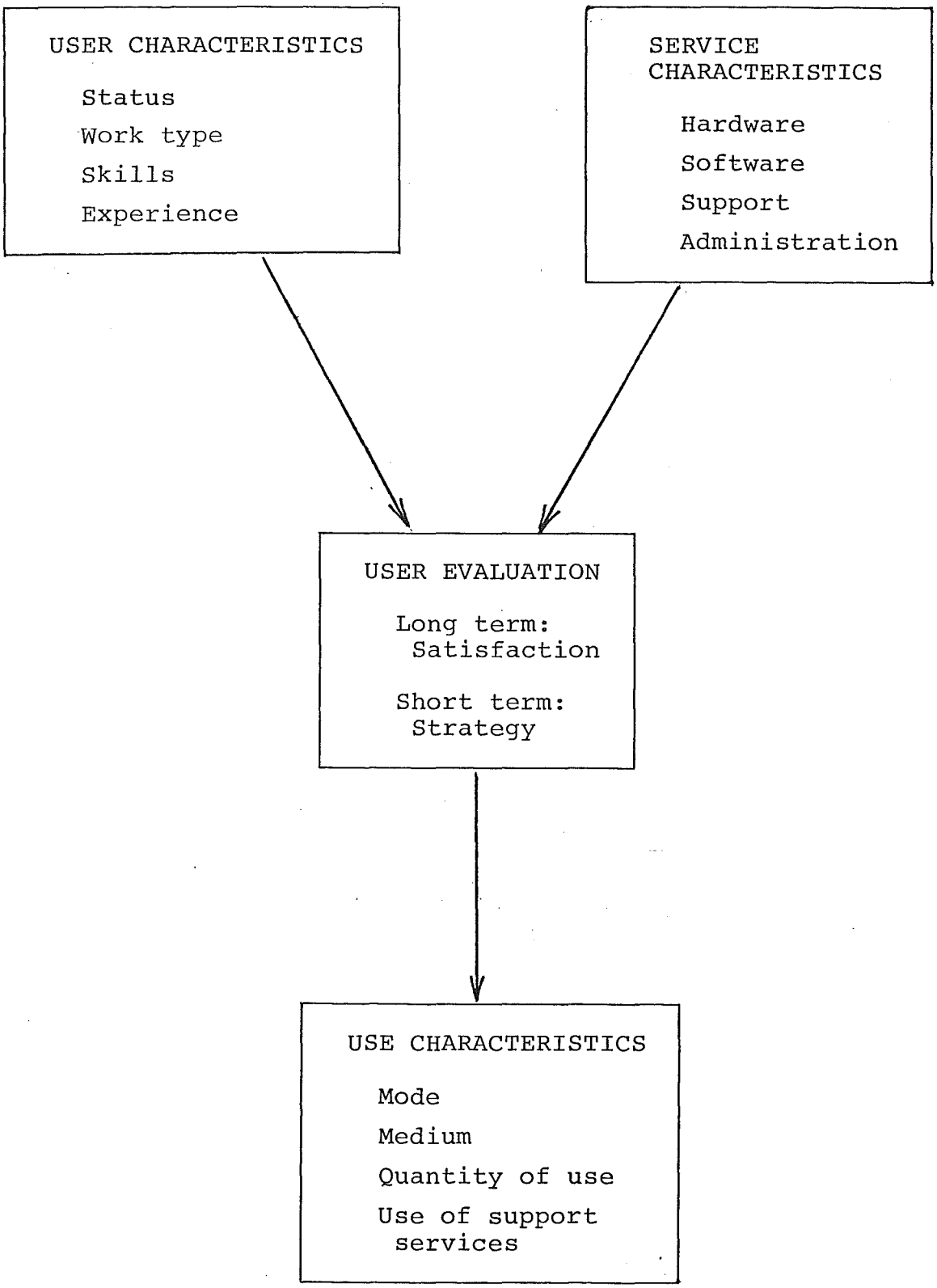
3.1.1 The Provision of Computing Services

Typically, university computer centres support many language compilers and statistical, numerical and other packages on medium to large mainframes. Some centres also provide separate small to medium sized systems for special purposes, such as handling high volumes of small student jobs, or serving the needs of the central university administration.

In addition to the processing capability provided by the hardware and software, computer centres offer a variety of support services. These usually include data preparation, software support, and informational and consultative services. Centres generally recognize the need for facilitating communication with users and allowing user feedback. Certain other functions of computer centres pertain to the

Figure 2

Summary of the Factors Under Study



allocation and administration of their resources: charging and distribution, long term planning and development, etc.

The actual services provided were considered to be of sufficient importance to the investigation to warrant a detailed description, for two reasons: first, the range of services implicitly defines the forms of interaction possible for the user, and second, the nature of the services, and their availability and cost to users are obvious influences on the user's evaluation. A model for the description of the services provided by a centre was developed and is shown in Figure 3. The computing services under study were described according to this template, and this description is given in Appendix C.

3.1.2 User Characteristics

Most users at universities are amateur programmers, although there are also naive users and professional programmers within the user population. Users in all categories were considered in this research, but no attempt was made to compare their computing needs, use of services or satisfaction.

User characteristics that were considered important in this research were the user's status or place in the university, the purposes for which the computer was used and the kind of work undertaken with it, the user's computing skills and the user's previous computing experience.

Eason *et al.* (1974) found that the organizational position of a user in the commercial environment was a major determinant of his/her work type and the specific tasks for which the computer was used. Considering the status of users in the university context, we saw a major distinction between staff and students. The computer centres at some universities such as Canterbury have, in addition, outside or external users.

The applications for which the computer is used could be categorized

Figure 3

A Model for the Description of the University Computer Centre Resource

1. SITE AND EQUIPMENT

   Hardware configuration:

   processors, peripherals and their organization.

   Job submission:

   the means provided to users, location of terminals and other facilities in user areas.

2. SOFTWARE

   Operating system, interactive and batch systems. Language compilers, packages and utilities.

3. USER SUPPORT

   Informational support:

   documentation, library, consultative services, courses, seminars, tours, publications - news, notices.

   User-Centre communication:

   formal feedback mechanisms.

   Clerical support:

   enquiries, project registration, accounts, supplies, bookings.

   Technical support:

   hardware and software development and maintenance.

   Operations support.

   Data preparation facilities.

4. ALLOCATION AND ADMINISTRATION

   Availability and access rules:

   hours, charging and funding, queue and priority structure.

   Organizational context:

   administrative structure, policy-making bodies, offical objectives, planning and review procedures.

(as other university activities often are) as either teaching, research or administration. However, we required a more detailed description of the kind of work undertaken with use of the computer. For the 1980 survey, the following categories were used: examination and analysis of data in research applications, finding the solutions to mathematical-type problems, information processing, studying computing, and using the computer as an aid to instruction. The field or discipline in which a user worked was also considered as a possible influence on his/her computing needs.

We hypothesized that the importance of the computer to the user's work was also relevant. The extent of the user's dependency might have implications for the user's approach and attitudes to computing.

Our experience indicated that certain users might have additional contact with the computing services by reason of particular computing-related responsibilities such as involvement with student classes, supervision of research that uses computers, or tenure of a departmental computer-related position.

The skills and experience of users formed another major area of user characteristics. These are personal attributes which could affect the use of computing facilities, and reciprocally, are affected by them. We decided that measures of the user's instruction in computing and his skills in the use of packages and languages were necessary. In the second study at Canterbury, we measured also the user's mathematical skill, and the user's opinion about the adequacy of this skill with respect to the requirements of his computing.

3.1.3 The Nature of the Interaction

The interaction between users and computer services can be classified according to the *medium* and *mode* of that use.

By the term *medium*, we refer to the physical means by which the

individual communicates with the system. Some users employ an interactive medium such as a visual display unit. Some use the batch medium, submitting programs and data on punched cards and receiving printed output in return. Batch use can be categorized according to whether users have direct access and control over input and output devices or whether their cards and printout are handled by an intermediate human operator. Some university users employ both batch and interactive media; by contrast the only form of communication between certain other users and the system is via another more direct user.

By the term *mode*, we refer to the software facilities employed by the user. In the university environment, we can identify two principal modes of interaction: programming and package use. In order to solve a problem, programmers write a recipe of instructions in a language which they have to learn. Package users write out instructions for the solution of a problem in a usually much simpler language. The instructions are interpreted as commands by a package which is an existing program or set of programs designed to solve a particular sort of problem.

Further to our classification of the forms of interactions according to medium and mode, we required measures of the amount of use that is made of the system and support services. These amounts vary considerably among university users; measures of use were required in order to test a large number of hypotheses about the nature of the interaction between the users and the service, for example, "Infrequent users have a relearning problem, as evidenced by their high use of documentation and consultative services".

3.1.4 User Evaluation and Effectiveness Measurement

User satisfaction was viewed as a component of the user's long term evaluation of the computing services. Eason *et al.* considered the long term evaluation to be formed on the basis of accumulated experience.

They considered that:

> "It is unlikely that this process will occur via a conscious decision procedure whereby evidence is weighed and assessed because no decision is required. It is more likely that the process involves the steady accumulation of information and the emergence of attitudes towards the system." (*op. cit.* p29)

Also, such general attitudes developed by the user were expected to influence any specific (i.e. short term) assessment the user made in using the system.

The literature reviewed in Section 2.3 confirmed that satisfaction is an attitude formed on the basis of individual experience. While recognizing the individuality of satisfaction, its determinants and its effects, we sought to observe common experiences of the users that influenced their satisfaction. For example, we were interested in the effects on the users' satisfaction of their competition for a share of a limited and constrained computing resource. Also, we considered service aspects for which their was substantial dissatisfaction to be critical areas of which a computer centre, whose objective is to meet the needs of its users, should be well aware.

Our definition of effectiveness arose from these considerations and the function of user needs as postulated by the behavioural model. For the purposes of this research, the effectiveness of a computer centre was defined to be *the extent to which it meeds the needs of its users*, as measured by the degree of satisfaction expressed by users concerning the computing services provided.

User satisfaction was measured according to the multiple facet approach described in Chapter Two. Satisfaction responses were elicited by questions of the form

"How satisfied are you with...?"

and measured on the following five-point scale:

RESPONSE CATEGORY	SCORE
Highly dissatisfied	-2
Dissatisfied	-1
Indifferent - neither satisfied nor dissatisfied	0
Satisfied	1
Highly satisfied	2
(No response)	Missing datum

It had been established that weighting of satisfaction data by a user-rated importance scale was unnecessary; hence no importance data were collected.

Our aim in selecting satisfaction topics was to make a comprehensive survey of those topics relevant to the use of computing services about which users had some feeling of satisfaction or dissatisfaction. We were guided by our knowledge of the local computing environment and the results of our first study.

Three broad categories of topics were formulated: those concerning batch services, those concerning interactive services, and certain general topics concerning the administration and support services. The reader is referred to the text of the questionnaires, which can be found in Appendices A and B, for the topics which were selected.

The raw data collected using the questionnaires were used to identify service aspects for which there was substantial dissatisfaction. The use of many of the same topics in the two questionnaires allowed some comparisons that reflected changes in the levels of user satisfaction over the time between the two surveys.

The satisfaction data were also used to test hypotheses regarding the level of satisfaction of particular groups of users with specific services. However, this line of investigation was not pursued very far because it failed to take account of the sometimes substantial correlations

between satisfaction variables. We believe that these correlations occurred because there existed factors underlying the users' responses; that is, to a measurable extent, several questions had recorded aspects of the same phenomenon. We hypothesized that user satisfaction arose as more fundamental attitudes to a small number of service aspects, or groups of related topics, e.g. batch, interactive and general areas.

Factor analysis techniques were used to detect such underlying factors in the raw satisfaction data. Factor analysis had previously been used for this purpose by McKaskill (1978) in his study, which we reviewed in Chapter Two. Detailed methodology was not given by McKaskill, and so this had to be developed.

The basic product of factor analysis was a mathematical description of a small number of factors that could be taken to account for a large proportion of the variance in the raw data. It was also possible to generate scores which represented the satisfaction of each individual with each factor. We used these scores to see how satisfaction varied with the user and use characteristics discussed in the previous sections. In addition, factor analysis output was used in the calculation of the effectiveness ratings which we devised to summarise the satisfaction of all users with each factor.

The nature of the factors which were exposed during our first investigation provided extra guidance for the choice of satisfaction topics for inclusion in the second investigation. In the same way, results of both investigations (given in Section 4.2) may be used to guide future research. In this regard, see the instructions given by Cattell (1978, p493-500) for conducting factor analytic research.

All the methods referred to above are described in detail in Section 3.3.

3.2 THE QUESTIONNAIRE SURVEY

The purpose of the questionnaire survey was to collect quantitative data from a large number of users. These data concerned their use of, and satisfaction with, the computing services. The resultant data base was to be used for a variety of statistical analyses which are described in Section 3.3.

3.2.1 Survey Design

The survey used a mailed, self-administered questionnaire. Users were sent questionnaires and asked to complete them and return them by a specified date. Recipients were not required to record their name or other contact information on the questionnaires unless they were willing to be interviewed as part of the follow-up exercise. Questionnaires could otherwise be identified only by the unique code assigned to them, which could be matched to a numbered list of all recipients. Each return was recorded on the master list, and at the due date a reminder letter was sent to non-respondents.

The main disadvantage of the mailed questionnaire is non-response, and, in particular, any bias introduced by it:

> "...almost invariably (those who furnish) returns are not representative of the original sample drawn; nonresponse is not a random process; it has its own determinants which vary from survey to survey." (Oppenheim, 1966, p34)

Oppenheim suggested that comparisons between early and late responses could provide some indication of the nature of response bias in a particular survey; non-respondents were thought to be more like late respondents than early respondents. In the 1980 survey, returns were coded "early" or "late", so as to allow some comparisons. These comparisons are included in an examination of the response to the two surveys given in Section 4.1.

3.2.2 Questionnaire Design

Certain requirements of the questionnaire arose from the nature of the survey as described above. The main concern was that the questionnaire was to be self-administered. Consequently it required a covering letter explaining the purpose of the survey, clear instructions for answering questions, a simple layout and questions that were easily understood and answered.

Certain other requirements arose through our desire to avoid coding and transcription of responses as an intermediate step before transferral of the data to computer media. Consequently, the questionnaire was designed so that respondents would code their own responses wherever possible, thereby minimizing post-administration coding. Furthermore, the questionnaire was designed so that coded responses could be key-punched directly, thereby eliminating an extra source of transcription errors.

The content of the questionnaires was determined largely by our behavioural model of the computer user. This model represented what we knew and hypothesized concerning the influences on user behaviour. Naturally, the model was developed and modified during the course of the project according to relevant literature and results that we obtained.

Another major influence on questionnaire content was the local computing environment. It was necessary to assimilate certain knowledge of the facilities and the way in which they were provided at Canterbury. Being on site and with some experience of the local facilities, we found no difficulty in this matter.

On this basis, a table of user characteristics was developed by Chen. From this table (reproduced in Figure 4) she formulated the initial questionnaire and conducted a pilot study involving forty users. This testing stage was essential: "The feedback from this preliminary survey was of great value in improving the layout and content of the questionnaire."

Figure 4

Questionnaire Topics, 1978 Survey

1. Description of the user
    - 1.1 status
    - 1.2 purpose for using the computer
    - 1.3 work (job) type
    - 1.4 previous background in computing
        - 1.4.1 instruction period
        - 1.4.2 instruction place
        - 1.4.3 knowledge of computing languages
    - 1.5 level of computing expenditure

2. Use of computing services
    - 2.1 mode
    - 2.2 medium
    - 2.3 use of consultative services
    - 2.4 use of informational media
    - 2.5 input preparation method
    - 2.6 output distribution method

3. Satisfaction levels
    - 3.1 batch use
    - 3.2 interactive use
    - 3.3 general facility use
        - 3.3.1 assistance with problems
        - 3.3.2 availability of staff
        - 3.3.3 adequacy and quality of ancillary services

Source: Chen, 1978: Table 5-1, p10.

(Chen, 1978, p11) The improved questionnaire that was used in the 1978 survey is shown in Appendix A.

The experience of the first survey and data analysis were of great benefit to the development of the questionnaire for the 1980 survey. The topics that were selected are listed in Figure 5, and the questionnaire is shown in Appendix B.

3.2.3 Population Determination

A major problem that was encountered in both surveys was determination of the user population. The criterion for inclusion was that a user should be an authorized user of the Burroughs central site system. Authorization is granted by the Computer Centre in the form of an account and user code. Certain accounts are the master accounts for a number of subaccounts; subaccounts are usually issued to groups of users, such as student classes, under the control of a supervisor.

In order to compile a complete list of users and the necessary contact information, several sources were used. These included mailing lists, monthly accounts, lists supplied by supervisors of subaccounts, and the Computer Centre's file of all user codes. Careful inspection revealed that much of the information was out of date or inconsistent. These problems were generally resolved with the assistance of the Computer Centre staff, department secretaries, or the users themselves. Inclusion of a user did not depend on the amount of use made of his/her account; it became obvious during the course of our work that many users are infrequent users. Some, for instance, may not have made their annual use of the computer for processing examination results at the time of the survey.

In the situation where a user held more than one user code, duplicate entries were removed from the penultimate list. In this way, a population list of 600 users and their addresses was produced from an

Figure 5

Questionnaire Topics, 1980 Survey

1. Status
2. Application and dependency
   - 2.1 application
   - 2.2 dependency
   - 2.3 field of work
3. Experience
   - 3.1 year of first computer use
   - 3.2 age
   - 3.3 amount of instruction in computing
   - 3.4 place of instruction in computing
   - 3.5 level of mathematics studied
   - 3.6 relative adequacy of mathematics skills
4. Contact
   - 4.1 computing-related responsibilities
   - 4.2 use of non-Centre facilities
   - 4.3 amount of use of Centre facilities
5. Mode and language skills
   - 5.1 languages used, proportions of use
   - 5.2 knowledge of major language and system command languages
   - 5.3 program writing method and purpose
6. Medium
   - 6.1 batch-interactive work proportion
   - 6.2 usual batch method
   - 6.3 input preparation method
7. Use of supportive services
   - 7.1 use of consultative services
   - 7.2 ownership and use of informational media
   - 7.3 attendance at Users' Group
8. Satisfaction
   - 8.1 batch
   - 8.2 interactive
   - 8.3 general

original figure of 900 user codes, for the 1978 survey. For the 1980 survey, the number of user codes was found to be 1,332, and the number of users was determined to be 829.

3.2.4 Sampling Technique

The collection of data from all users at Canterbury would have provided a true representation of the situation. However, collection, handling and analysis of the data from 600 to 800 cases was infeasible, even with the aid of a computer. As a result, it was necessary to select a sample representative of the user population.

The choice of sample size was essentially a trade-off between processing constraints and sampling error. Sampling error can be estimated as follows: given a sample of size N that has been selected at random from a population of size U, the sampling error inherent in estimating a population proportion from a sample proportion p, is

$$\pm t \sqrt{p(1-p)/(N-1)} \sqrt{1-N/U}$$

where t is Student's t statistic, dependent on N and the desired confidence level. Sampling error reaches a maximum value when the sample proportion is 0.5. For a sample of size 301 drawn at random from a population of 829 (using actual figures from the 1980 survey), with 95% confidence we could say that the sampling error would not exceed 4.5%. Taking into account a response rate of 64% for the survey, but not any bias inherent in this reduced sample, the maximum sampling error increases to 6.2%. Sampling error of this size was acceptable.

To increase the reliability of certain results, the technique of *proportionate stratified sampling* was used in the survey design. With this technique the population is divided into various strata, and from within each stratum an independent random sample is taken. The sampling proportion used is the same for each stratum; this ensures that with respect to the characteristic used for stratification the sample

contains the desired representation of the population. The main advantage of stratified sampling over simple random sampling is that it tends to give a more precise estimate of population values, in the sense that

> "...the sampling error of a mean or a proportion as estimated from a stratified sample is nearly always smaller than the standard error in a simple random sample of the same size." (Butcher, 1965, p7)

However, substantial gain can only be achieved when the basis of stratification is related to the variable(s) under consideration.

The basis of stratification that was employed in the two questionnaire surveys was the division of the user population by university department or school. The 1978 survey used an additional categorization of users: student vs staff. Table 2 shows the sample that was selected. This sample, of size 295, was selected from the population of 600 users. The sample that was selected in the 1980 survey is shown in Table 3; the number of responses by department is also shown. The student-staff categorization was dropped in this survey because of the difficulty of discriminating postgraduate students from staff. A sample of size 301 was chosen from 829 users.

Table 2

Sample Composition, 1978 Survey

DEPARTMENT	STAFF	STUDENTS	TOTAL
Accountancy	3	-	3
Botany	1	-	1
Business Administration	-	5	5
Chemistry	7	4	11
Chemical Engineering	4	5	9
Civil Engineering	10	6	16
Computer Science	3	63	66
Economics	3	4	7
Education	4	1	5
Electrical Engineering	3	8	11
English	1	-	1
Environmental Sciences	-	-	-
E.R.A.U.	-	-	-
Extensions Studies	-	-	-
Forestry	2	2	4
French	2	-	2
Geography	5	3	8
Geology	-	1	1
History	-	1	1
Mathematics	5	8	13
Mechanical Engineering	4	7	11
Mt John Observatory	-	1	1
Music	1	-	1
Physics	7	11	18
Political Science	-	-	-
Psychology/Sociology	4	4	8
Zoology	3	7	10
Lincoln College	17	32	49
COLUMN TOTAL	89	173	262
EXTERNAL USERS			33
SAMPLE TOTAL			295

Source: Chen, 1978: Table 5-2, p14.

Table 3

Population and Sample Composition and Number of Returns by Strata, 1980 Survey

STRATUM	POPULATION COMPOSITION	SAMPLE SIZE	NUMBER OF VALID RETURNS
Accountancy	7	3	3
Botany	3	1	1
Chemical Engineering	18	7	5
Chemistry	21	8	6
Civil Engineering	37	13	12
Computer Science	140	51	44
Economics	30	11	9
Education	12	4	1
E.R.A.U.	2	1	1
Electrical Engineering	103	37	16
English	4	1	-
Environmental Sciences	2	1	-
Extension Studies	3	1	1
Forestry	30	11	6
French	3	1	1
Geography	26	9	7
Geology	2	1	1
History	5	2	1
Mathematics	19	7	3
Mechanical Engineering	9	3	2
Mt John Observatory	2	1	-
Physics	62	22	12
Political Science	27	10	2
Psychology	16	6	4
Sociology	10	4	3
Zoology	17	6	3
Lincoln College	108	39	25
Miscellaneous	6	2	-
External Users	105	38	23
TOTAL	829	301	192

3.3 ANALYSIS OF SURVEY DATA

The overall data analysis plan comprised a series of stages, which are shown below.

(a) Establishment of the data base.

(b) Identification of predominant user and use characteristics.

(c) Examination of satisfaction data and derivation of the effectiveness measures.

(d) Explanation of the variation in satisfaction levels in terms of user and use characteristics.

The procedures and statistical methods that were used in this plan are described in the sections which follow.

Without an analysis package, such as the one used in this research, it would have been impossible to complete development of our investigative technique in the time available. We chose the Statistical Package for the Social Sciences, which was the most heavily used statistical package at Canterbury University. More importantly, SPSS is widely available, provides an adequate range of statistical methods and is well-documented (see Nie *et al.*, 1975).

3.3.1 Establishing the Data Base

Coded responses were read directly from the questionnaires and punched onto cards. The cards were incorporated in an initial job that created a permanent SPSS system file on disk. This data base contained not only the data, but also considerable data definition information, such as names and descriptive labels for the variables, and labels for the response alternatives for each question, where this was applicable. The initial job also allowed recoding and transformation of the raw data, and creation of new variables from the existing ones.

At this stage it was necessary to verify the data and any transformations that had been made. This was achieved by listing all

the data, and checking it case by case against the questionnaire returns. An additional check that was made involved the generation of simple tables that summarised the responses to each question. In order to make alterations to the data, the cards were corrected and the initial job was repeated.

Once established in this way, the data bases (one from the 1978 survey and one from the 1980 survey) were available for statistical analysis. The next step involved categorizing all the variables according to their measurement levels. This was necessary in order to comply with the requirements of the different statistical methods that were to be used. We organized the measurement scales used in the questionnaires into four groups: dichotomous, nominal, ordinal and interval.

It was desirable to test the suitability of the many ordinal-level variables for treatment as interval-level variables; if this could be done, we could make use of the more powerful parametric statistical methods available for interval-level variables. The use of ordinal data in this way is common practice, despite some controversy among statisticians:

> "If the dependent variable is measured on an ordinal scale, there is some debate as to whether the investigator is restricted to use of those nonparametric statistics intended for use with ordinal data. Some statisticians feel this is a critical distinction which must be observed. However, the position taken here is that the distinction between ordinal and interval data may be ignored in most circumstances." (Roscoe, 1975, p194)

We decided to ignore this distinction for those variables exhibiting a distribution that sufficiently approximated the normal distribution:

> "The parametric statistics ... require that the sampling distribution of the statistic closely approximate a normal distribution. The distribution of the statistic is in part a function of the distribution of the variable. If the dependent variable is normally distributed, there need be no concern about the assumption of normality." (Roscoe, 1975, p195)

A suitable test for determining normality is the Chi-square test for goodness-of-fit. The standard procedure can be found in elementary texts (for example Roscoe, 1975, p247-253), and an example of the computation is given in Table 4.

Chi-square goodness-of-fit tests were performed for all interval and ordinal variables from the two surveys (excluding those which were not used directly). Of these variables, only one was rejected using a test at the 0.05 level of significance; this variable was recorded and treated as dichotomous.

3.3.2 Univariate and Bivariate Statistical Methods

All stages of the data analysis plan required the use of common univariate and bivariate statistical methods. The desired univariate statistics were obtained by use of the SPSS subprograms FREQUENCIES and CONDESCRIPTIVE. Bivariate statistics that were used are shown below:

MEASUREMENT LEVELS		DISPLAY OF JOINT DISTRIBUTION	MEASURE OF ASSOCIATION
VARIABLE A	VARIABLE B		
Dichotomous or Nominal	Dichotomous or Nominal	Cross-tabulation	Chi-square statistic
Dichotomous	Interval	Mean score on B by categories of A	Student's t statistic
Nominal	Interval	Mean score on B by categories of A	F statistic
Interval	Interval	Cross-tabluation or plot	Pearson's r statistic

To obtain this information the following SPSS subprograms were used:

(a) CROSSTABS for cross-tabulation, Chi-square value and significance test.

Table 4

Example Chi-Square Goodness-of-Fit Test

Variable:	Satisfaction with data preparation service
Question:	35·1 (1980: see Appendix B)
Hypothesis:	The observed sample has been drawn from a normally-distributed parent population
Alternative:	Parent population not normally distributed
Rejection:	Calculated Chi-square value exceeds tabulated value for (a = 0.05, df = N-3)

CATEGORY	SCORE	NUMBER OF RESPONSES
1	-2	2
2	-1	5
3	0	36
4	+1	84
5	+2	42
Total number of responses		169
Mean score		0.94
Standard deviation		0.83

BOUNDARY VALUES		PROB.	EXPECTED NUMBER, E	OBSERVED NUMBER, O	$\frac{(E-O)^2}{E}$
ACTUAL	STANDARD.				
-1.5	-2.945	.0016	0.27	2	11.06
-0.5	-1.738	.0395	6.68	5	0.42
+0.5	-0.532	.2563	43.31	36	1.24
+1.5	+0.674	.4525	76.47	84	0.74
		.2501	42.27	42	0.00
TOTAL		1.0000	-	169	13.46

Chi-square value:	X^2 = 13.46
Degrees of freedom:	df = 166
Since df > 100, use Normal approximation to Chi-square distribution:	$Z = \sqrt{2X^2} - \sqrt{2df - 1}$
Amended rejection region:	Z > 1.64
Normal deviate:	z = -13.00
Decision:	retain null hypothesis

(b) T-TEST for mean and standard derivation, F test for comparison of sample variances, Student's t statistic calculated for pooled or separate variance estimates, and two-tailed significance test.

(c) ONEWAY for analysis of variance, F statistic and significance test, and multiple classification analysis.

(d) PEARSON CORR for Pearson's product-moment correlation coefficient, and one or two tailed significance text.

(e) SCATTERGRAM for plotting of joint distribution.

In this research, two-tailed tests were used for establishing the significance of Student's t and Pearson's r statistics.

It is implicit in the presentation of all bivariate results in subsequent chapters that the appropriate statistics (t, r, F or X^2) were significant.

All results concerning the identification of user and use characteristics, such as those presented or referred to in Section 4.1, were based on the 0.01 level of significance, except where otherwise stated. All results concerning the explanation of variations in satisfaction levels, such as those presented or referred to in Sections 4.1.8 and 4.2, were based on the 0.05 level of significance. The abbreviation 'N.S.' denotes that the appropriate statistic was not significant at these levels.

3.3.3 Identifying Critical Service Aspects

One of the most immediate uses of raw satisfaction data was the identification of service aspects for which there was substantial dissatisfaction. Three methods for achieving this were considered.

The first method used the mean score. This was a valid measure of the central tendency of the sample; on the other hand, it did not directly indicate the amount of dissatisfaction.

The second method used an index similar to that devised by van der Hart (1979). The original index, which was described in Section 2.3.2, used the numbers of dissatisfied and highly dissatisfied users (ND and NHD, respectively) and incorporated importance ratings and a constant scaling factor. It was established in Section 2.3 that the use of importance data was unnecessary and, like the constant, this component was ignored in our index:

Index = ND/N + 2 x NHD/N,

where N is the total number of respondents.

A major disadvantage of the above method was that index values lacked established statistical theory and well-defined meaning. In response to this problem we devised a third method which used the proportion of the total number of respondents who were dissatisfied (including those highly dissatisfied).

It is important to notice that all three measures were based on the number of valid responses, and not the total number of users in the sample. Consequently, they gave equal prominence to all service aspects, regardless of how widely each service was used.

The three methods were compared using empirical data from the two surveys. After considering the results of this comparison (given in Section 4.1.8), we decided to use the proportion dissatisfied measure to identify critical service aspects.

3.3.4 Factor Analysis of Satisfaction Data

In Section 3.1.4, we gave a synopsis of the purposes for which factor analysis was used in this research. In this section, we describe the specific methods which were used.

Factor analysis involves at most five stages, all of which are briefly described below. Since all stages except the fourth are usually computer-based, the choice of methods is limited by the computer

software available. An adequate range of methods is provided by the FACTOR subprogram of SPSS. In addition, considerable control over the action of the algorithms is allowed.

(a) Preparation of the correlation matrix. At this stage, the respondents and variables to be considered are selected. Then the association between each pair of variables is evaluated.

In each survey, satisfaction questions had been asked about batch services, interactive services (CANDE), general support services and miscellaneous topics. Since not all respondents used all services, and in particular since at most half of the respondents used CANDE, many of the satisfaction responses were missing. Factor analysis of the whole data matrix, i.e. all cases (respondents) and all satisfaction variables from a data base, was not possible because of these missing data. Correlations between variables would have been calculated from different segments of the user sample, and factor analysis of the resulting correlation matrix might have produced misleading results. (Also, such a matrix might have been singular, which would have prohibited its inversion, necessary at a later stage.)

Our immediate task was to make use of the available data in the most meaningful way. After some experimentation we decided to use the satisfaction data from each data base for two analyses: a batch analysis and a CANDE analysis. For the batch analysis we used the responses to batch and general questions of any respondent who had answered at least one batch question. In this way, we hoped to expose factors relevant to batch use (even though the responses of persons who used CANDE would be included). A very few respondents who made no direct use of the services were excluded. The CANDE analyses were set up similarly; we intended to expose factors relevant to interactive use (even though the responses of CANDE users to batch questions would be excluded).

All satisfaction variables were subjected to the test for normality described in Section 3.3.1. All were found to be suitable for treatment as interval level variables and so Pearson's product-moment correlation coefficient was used to measure the association between them. Missing data were excluded by pairwise deletion; that is, in the calculation of a particular coefficient, a case was excluded only if the value of either of the variables was missing. In this way, the analysis made use of all available data.

(b) Extraction of the initial factors. On the basis of the relationships defined by the correlation matrix, a set of new and orthogonal variables are sought. These new variables, the initial factors, are described by a matrix of loadings between each factor and each variable.

The common approach to achieving this factoring is known as classical factor analysis. It supposes that the observed correlations are mainly the results of some underlying regularity in the data. Its basic postulate is that each observed variable is influenced by various determinants, some of which are common to other variables, while others are not shared by any other variable. That is, there exists for each variable both *common* and *unique* (or residual) variance.

The factoring method that was chosen was principal factoring with interation (PA2). Initial estimates of the communalities, given by the square multiple correlation between a given variable and the rest of the variables, are improved by an interative procedure. According to the SPSS authors:

> "It may be noted that PA2 can handle most of the initial factoring needs of the user. At present this is the most widely accepted factoring method. Those who have limited experience with factor analysis might do well to stay with this method." (Nie *et al.*, 1975, p480)

The number of factors to be extracted was limited by the requirement that eigenvalues should not be less than 1.0.

(c) Rotation to the terminal solution. An important characteristic of the factor solution is its indeterminacy: there are many possible solutions to a given factoring problem, and all are mathematically equivalent. Generally, the initial factor matrix undergoes the process known as rotation in which it is transformed into an equivalent but simpler and perhaps more useful and more meaningful solution. The terminal solution is most commonly expressed as a factor pattern matrix; this matrix describes the rotated factors in terms of their influence on the variables.

The many rotation methods available can be classified as either *orthogonal* or *oblique*, depending on whether the factors are required to be uncorrelated or not. In this research it was decided, after some experimentation, to use an orthogonal rotation method (VARIMAX) which seeks to maximise the variance of the squared loadings in each column of the factor matrix. The effect was to simplify the composition of the factors. According to the SPSS authors, this is the most widely used method.

(d) Identification and interpretation of factors. This stage involves the researcher in considering the structure of the relationships between the rotated factors and the variables, as shown by the factor pattern matrix. This matter has been dealt with by Cattell (1978, p229-270). In part he said,

> "...one looks, after a glance at the positive loadings, first at the negative loadings and then turns around to examine the nature of those variables which do not load that factor at all. Both procedures require that one keep freshly in mind also the question of what variables were in fact never entered into the experiment."
> (*op. cit.* p231)

Cattell also mentioned other considerations for the investigator, such as the existence of well-established theory and factors known to have influence in the field of study. The only guiding literature in the present field was the work by McKaskill (1978) which was reviewed in Chapter Two; the structure of the factors exposed by McKaskill was

shown in Table 1.

(e) Calculation of factor scores. This stage begins with the construction of the factor estimate matrix, which comprises regression weights or factor score coefficients between each factor and each variable. Then, each individual's factor scores are calculated according to the formula:

$$S_{ik} = \sum_{j=1}^{n} (X_{ij} - M_j)/D_j \times W_{jk},$$

where S_{ik} = score of individual i on factor k;

X_{ij} = raw score of individual i on variable j;

M_j = mean for variable j;

D_j = standard deviation for variable j;

W_{jk} = factor score coefficient for variable j and factor k;

n = number of raw score variables.

These factor scores were used to indicate the satisfaction of an individual with the underlying theoretical dimensions (the factors) which were exposed by the previous stages. Hence, an individual's satisfaction was represented by a vector of factor scores which can be denoted thus:

$\underline{S}_i = (S_{i1}, S_{i2} \ldots S_{im})$, where m = number of factors.

Subprogram FACTOR was used to calculate factor scores for all cases for which no greater than 25% of the required raw data were missing; missing data for these cases were replaced by the population mean. Factor scores were subsequently merged with selected portions of an existing data base and the whole was saved as a new SPSS system file.

3.3.5 Adjusted Factor Scores and Effectiveness Ratings

As shown by the formula above, factor scores were calculated from the normalized raw data. Consequently, they indicated an individual's levels of satisfaction relative to those of other users.

Using factor scores in this form we were able to examine the influence of various personal and situational variables on user

satisfaction. However, these scores did not summarise the absolute level of satisfaction of all the users with each factor. (It can be shown that the expected value of these factor scores is zero; hence the mean of the scores on each factor would not suffice.) Since summary measures were highly desirable as indicators of the overall effectiveness of the service, we developed the method described below.

First, it is necessary to consider the factor scores which would be calculated for an individual with all-zero raw satisfaction data, i.e. all "indifferent" responses. Factor scores for this hypothetical user, 'h', would be given by:

$$S_{hk} = -\sum_{j=1}^{n} M_j / D_j \times W_{jk}.$$

These scores form a vector thus:

$$\underline{S}_h = (S_{h1}, S_{h2} \ldots S_{hm}).$$

The score of the "indifferent" individual on a particular factor would not necessarily be zero, since its calculation depends on the mean and standard deviation of each variable. Rather, this score indicates his level of satisfaction relative to those of all other users.

Second, the score of the "indifferent" user provides a frame of reference for the interpretation of the scores of other users. Just as the "indifferent" response marked the "zero-point" of the measurement scale for the raw data, the factor score of the "indifferent" user marks a "zero-point" on the distribution of calculated factor scores. The levels of satisfaction of any individual, 'i', can be considered relative to these zero-points thus:

$$\underline{S}'_i = \underline{S}_i - \underline{S}_h.$$

We will henceforth refer to $\underline{S}_i$ as an individual's *raw* factor scores and $\underline{S}'_i$ as his *adjusted* factor scores. All factor scores presented in subsequent chapters are adjusted factor scores.

Third, since the adjusted factor scores indicate the levels of satisfaction of an individual user relative to a fixed standard, they can be used as the basis of the desired overall measures of effectiveness. These measures, which we will call *effectiveness ratings*, are defined as *the expected values of the adjusted factor scores*.

Since the expected values of the raw factor scores are zero, it follows that the expected values of the adjusted factor scores are simply $-\underline{S}_h$. In other words, each effectiveness rating indicates the distance of the sample mean from the zero-point. These ratings are mathematically described by:

$$E_k = \sum_{j=1}^{n} M_j/D_j \times W_{jk}.$$

The ratings for all factors form a vector thus:

$$\underline{E} = (E_1, E_2 \ldots E_m).$$

In practice, it is usually necessary only to obtain the raw factor scores of an actual "indifferent" user and invert them, since $\underline{E} = -\underline{S}_h$. If these are not available, they can be calculated from the means, standard deviations, and factor score coefficients, according to the formula given above.

3.4 USER INTERVIEWS

The factor scores calculated from each user's questionnaire responses were useful measures of the user's satisfaction with the services. They enabled us to select and interview users with known levels of satisfaction, and to seek to explain why users felt the way they did.

It was possible to select a small number of users whose factor scores collectively spanned the whole distribution of scores on each factor. In this economical way, we were able to verify the results of our data analysis and obtain detailed information directly from the users.

3.4.1 Selection of Interview Subjects

At the time of selecting the first group of users to be interviewed, we were most interested in the batch factor analysis, which included nearly all respondents to the first survey, and the prominent PEOPLE factor, in particular. Consequently, 20 users were selected on the basis of their batch factor scores so that each decile of the PEOPLE factor and each quartile of the other factors was adequately represented. These follow-up interviews were held almost 18 months after the 1978 questionnaire survey; nevertheless, they were very valuable.

Follow-up interviews for the 1980 survey were conducted within three or four months of the survey. In total, 22 users were selected, providing representation of each quartile of the distributions of both batch and CANDE factor scores. Selections from the factor scores of each analysis were made according to the method described below.

First, the questionnaire data were sorted according to users' scores on a particular factor. These scores and the survey codes used to identify users were listed, and then the quartiles of the distribution were established. This step was repeated for each factor.

Selections were then made at random from the scores in each quartile of the distribution of each factor. As each user was selected, his/her scores on all factors were recorded. Selections were made from each factor in turn until the desired representation (typically, two or three users) was achieved for each quartile of every factor.

Two checks were made to confirm that selected users were willing and able to be interviewed. In the follow-up to the 1978 survey, the first check was to examine users' questionnaire returns, since users had been asked to indicate their willingness, etc. by providing contact information. In the 1980 survey, the users' willingness to be interviewed had been coded and stored within the data base; by listing this information with the factor scores, this first check was quite simple. The second check was made by contacting users, usually by telephone, to confirm their availability and to establish an appointment.

Coding of the users' willingness to be interviewed in the 1980 survey allowed us to examine any bias introduced by this factor to the selection process; results are given in Section 4.3.

3.4.2 Interviewing Technique

Interviews took place either at user's work place or at the interviewers' work places, according to the user's preference. Our preference was to visit the user in his/her familiar surroundings.

The interview team generally consisted of two persons. This had several advantages over the normal one-interviewer situation. Collectively, two interviewers had more experience to draw on in understanding and other interviewing skills. Individually, the interviewers were under less pressure to take notes and maintain rapport. One member of the team could adopt the central role of investigator while the other monitored the direction of the questionning, picked up missed cues and took extensive notes. These roles were swapped

frequently during each interview, and this strategy proved quite effective.

Before each interview we read through the interviewee's questionnaire return, and examined his/her factor scores. Subjects were not asked directly to explain their responses or scores; however, these data were used as background information for guiding the interview and as pointers to areas of concern.

Interviews required approximately one hour, and they were largely unstructured. We were not seeking to collect standardized data; rather to record information of greater depth and subtlety than that of the questionnaire survey. For this purpose, frequent use was made of such questions as the following:

"How do you feel about...?"

"Do you use...?"

"Have you ever had problems with...?"

Some of the responses were recorded verbatim; others were paraphrased or summarized.

For the interviews that followed the 1978 survey, no formal means were used for topic control. For the 1980 interviews, a schedule was developed. This acted as a reminder list of topics to be covered and as a general guide for the interview; however, digressions were allowed, and these were often beneficial. This schedule is shown in Figure 6.

3.4.3 Interview Reports

During the interviews, notes were taken by both interviewers. Afterwards, these two sets of notes were read through and discussed.

For those interviews that followed the 1980 survey, reports were prepared from the questionnaire returns and interview notes. Each report summarized the information that had been collected concerning a particular user, and the conclusions that were drawn from the interview.

Figure 6

Interview Schedule, 1980

1. Introductions, explanation of the nature and purpose of the study and, in particular, the interview.

2. The applications for which computers are used, the computing requirements of those applications, software developed, languages/packages used, equipment used.

3. Use and evaluation of the batch service, attractive and deterrent aspects.

4. Use and evaluation of the interactive service, attractive and deterrent aspects.

5. Feelings about allocation of the central computing resource, charging and the allocation of funds.

6. Informational support: requirements, use, awareness and evaluation of documentation and consultative services; problems occurring and how they are handled.

7. Operational support: contact with operations staff and evaluation.

8. Data preparation service: use and evaluation.

9. Users' Group: attendance, perceived role, value.

10. Developments: projected changes in applications and use; plans for conversion to new machine.

11. Catch-all: other matters the user wishes to present.

3.5 GUIDE TO USE OF THE TOOL

In this chapter we have described the methods which were used in this research in sufficient detail to allow replication. Some additional guidance is necessary for proper use of the management tool which was developed, and this is given below.

Use of the tool requires official support and cognizance to be effective. The research team should comprise two persons, at least one of whom should be an outsider (that is, neither a local user or centre staff member). It is important that the team establishes liaison with a readily accessible centre staff member, because local knowledge is essential. The team should have an understanding of the use and purpose of the statistical methods involved, and some capability for using a software package that provides these methods.

We estimate that use of the tool requires 4 to 6 person-weeks of work spread over 3 to 4 months. The process involved is summarised in Figure 7. As shown by the illustration, some importance is placed on the acquisition of knowledge of the local computing environment. This is necessary in order to ask meaningful questions and to provide a frame of reference for the interpretation of results.

Subsequent to its development and use at Canterbury, the tool has been used at another centre by Ms Chrystine Burnside. She examined the effectiveness of computing services provided at Otago University, and her report (Burnside, 1981) contains her findings regarding this effectiveness and the portability of the technique. She said:

> "Use of the tool has shown that the concepts behind it and the methods it uses are sound. It is also relatively easy to implement, the major difficulty being in drafting a suitable questionnaire." *(op. cit.*, p29)

Future researchers may be guided by the questionnaires developed for the Otago study (Burnside, 1981, p43-59) and for the present study (see Appendices A and B), and the results of these investigations.

Figure 7

Summary of the Investigative Process

1. FAMILIARISATION

   - Establish liaison
   - Get hands-on experience with the system(s)
   - Interview a few users
   - Obtain user population lists
   - Produce a written description of the services to be studied

2. QUESTIONNAIRE SURVEY

   - Initial draft and pilot run
   - Redesign, check and print
   - Draw sample, and distribute questionnaires
   - Collect and record returns
   - Produce and distribute reminder letters
   - Check all returns for validity and legibility and code open-ended responses

3. DATA ANALYSIS

   - Keypunching
   - Data definition run
   - Verify data against questionnaires
   - Produce summaries of responses
   - Establish major patterns of user and use characteristics
   - Generate factors, factors scores and effectiveness ratings
   - Examine factors influencing effectiveness
   - Select interview subjects

4. INTERVIEWS

   - Contact and interview users
   - Write up interviews and summarise findings

CHAPTER FOUR

RESULTS

Development of the tool for measuring effectiveness required two investigations of the services provided by the University of Canterbury Computer Centre. The first questionnaire survey was conducted by Chen in September of 1978, and the second was carried out as part of the current project in July of 1980. These surveys provided data bases which allowed us to identify important characteristics of the users' interaction with the services and the major factors underlying their satisfaction responses. We were able to measure the effectiveness of the services on those factors and also to see how the satisfactions of individual users varied according to their personal characteristics and patterns of use.

Users with known levels of satisfaction on the different factors were selected and interviewed. From these interviews we obtained practical explanations for their satisfaction levels. The interviews helped to validate our measurements of user satisfaction and the results obtained through the analysis.

These investigations showed that the technique could be used to obtain, by economical means, reliable results that could be used by computer centre management.

The results of the two investigations are described and compared in this chapter. The reader may wish to refer to the description of the computing services in Appendix C. Statistical results are presented here as described in Section 3.3.2.

4.1 REVIEW OF SURVEY DATA

The data collected in the two questionnaire surveys provided considerable information about the user population, the kinds of work that were being done, and the ways in which the services were used. On its own, this sort of information is useful to computer centre management; it is also necessary background information for the construction of the effectiveness measures, the interpretation of the results of these analyses and for conducting interviews with users.

The review begins with an analysis of the response rates and possible response bias. Then, important user characteristics and patterns of use are sought by examining the survey data in groups that correspond to components of the behavioural model.

Finally, the user satisfaction data are examined, and some preliminary exploration of the relationships between user satisfaction and user and use characteristics are reported.

Throughout this chapter, numbers prefixed by 'A' or 'B' are used to identify questions from the 1978 and 1980 questionnaires respectively. The reader may use these numbers to refer to the text of questions and the summaries of responses which are given in Appendices A and B.

4.1.1 Analysis of Response

The response rates for the two surveys were 63% and 64%, as detailed in Tables 5 and 6. The literature suggests that such response rates are not unusual for surveys of this kind.

Some insight into the reasons for non-response was gained by examining information supplied by or on behalf of non-respondents. In the 1978 survey, 22 questionnaires were returned unanswered "...for reasons such as the user being away on sabbatical leave, having left the university, unable to be contacted or preferring not to fill in the questionnaire because (he/she) had not made any recent use of the

Table 5

1978 Survey Response

VALID RETURNS	187	(63%)
INVALID RETURNS		
Blank	22	(8%)
Nil	86	(29%)
Total	108	(37%)
TOTAL FOR SAMPLE	295	(100%)

Source: Chen, 1978:p17

Table 6

1980 Survey Response

VALID RETURNS		
Early	156	(52%)
Late	36	(12%)
Total	192	(64%)
INVALID RETURNS		
Blank	20	(7%)
Nil	89	(29%)
Total	109	(36%)
TOTAL FOR SAMPLE	301	(100%)

services." (Chen, 1978, p17). In the 1980 survey, 20 questionnaires were returned unanswered for similar reasons.

These results suggested one source of error and one possible source of bias. First, the presence of each name on the population lists or clerical records from which the samples were drawn did not indicate the availability of that user to complete a questionnaire. Second, a small number of recipients, believing that they had nothing of value to contribute, did not reply, despite a strong request in the covering letter encouraging them to do so. Any bias introduced as a result of this effect would be towards the more concerned or more involved users.

Further information about possible response bias was obtained from the 1980 survey, since the department, discipline and account type of all users in the sample were known. The only significant cross-tabulation was with respect to department. Response rates by department, previously shown in Table 3, are given in Table 7 in a more condensed form. No reason for this variation in response rates was obvious.

Questionnaire returns in the 1980 survey were coded "early" or "late" so as to allow comparisons that, according to Oppenheim (1966), could indicate the nature of the response bias. Comparisons of the mean scores of the two groups on all interval and ordinal level variables revealed only one significant difference: late respondents spent considerably less money on computing per month - approximately $16, as opposed to $34 for early respondents. This particular result, and the absence of other differences, tended to confirm our suspicion that, in general, non-respondents were less involved in computing.

One final test supported this suspicion. For each user, the mean and standard deviation of all valid satisfaction responses were calculated. Then the scores of the early and late groups on these two new variables were compared. While late respondents did not differ from early respondents in their overall level of satisfaction, their

Table 7

Response Rates by Major Department, 1980 Survey

DEPARTMENT	NUMBER OF VALID RETURNS	SAMPLE SIZE	RESPONSE RATE
Civil Engineering	12	13	92%
Computer Science	44	51	86%
Economics	9	11	82%
Geography	7	9	78%
Chemistry	6	8	75%
Lincoln	25	39	64%
External	23	38	61%
Miscellaneous	30	52	58%
Forestry	6	11	55%
Physics	12	22	55%
Electrical Engineering	16	37	43%
Political Science	2	10	20%
OVER ALL	192	301	64%

NOTE: The Chi-square statistic for the cross-tabulation of response/nonresponse by major department was signficant at the 0.01 level.

standard deviations were smaller. That is, the spread of satisfaction responses for a typical late respondent was smaller than that of a typical early respondent.

We concluded that the only apparent sources of response bias were the slight trend towards fewer responses from less active and involved users, and the variation in the response rates of the major departments (shown in Table 7).

4.1.2 Status and Work Type

Questions from the 1978 survey that concerned the user's status and work type were:

A1	Status
A2	Dependency
A3.1	Major work type: alternative one
A3.2	Major work type: alternative two

The following questions were employed in the 1980 survey:

B1	Status
B2	Application
B3	Dependency
B4	Field of work
B11	Instruct classes
B12	Supervise research
B13	Computing-related position

In addition, a variable indicating the user's discipline was derived from the survey code (SVC). The original smaple was sorted by strata before the unique numbers forming the survey code were assigned, and so it was possible to re-establish the strata within the data base. Since the strata corresponded to university departments, a department variable was created. Then, by aggregating groups of departments, the more useful discipline variable was derived.

Tables 8 and 9 indicate the kinds of work undertaken by users in different status categories. Table 10 shows the kinds of work undertaken by users in different disciplines. It is clear that the user's application is highly dependent on his/her discipline or department. Computer Science users were predominantly undergraduate students studying

Table 8

Major Work Type by Status, 1978 Survey

A3 MAJOR WORK TYPE	A1 STATUS				TOTAL
	Staff	Postgrad.	Undergrad.	External	
Number crunching	24	18	9	4	55
Package analysis	17	15	1	7	40
Data processing	17	6	5	8	36
Developing models	7	4	5	1	17
Teaching	3	0	0	5	8
Learning	1	0	29	1	31
TOTAL	69	43	49	26	187

Table 9

Major Application by Status, 1980 Survey

B2 MAJOR APPLICATION	B1 STATUS				TOTAL
	Staff	Postgrad.	Undergrad.	External	
Data analysis	34	18	2	12	66
Math.-type problems	19	20	16	1	56
Info. processing	6	1	0	2	9
Studying computers	2	1	41	0	44
Teaching aid	4	0	0	10	14
TOTAL	65	40	59	25	189

Table 10

Major Application by Discipline, 1980 Survey

B2 MAJOR APPLICATION	DISCIPLINE						TOTAL
	Comp. Science	Eng. School	Sciences	Arts	Lincoln College	External	
Data analysis	0	7	20	13	17	9	66
Math.-type problems	0	26	12	11	6	1	56
Info. processing	1	1	2	3	0	2	9
Studying computers	43	1	0	0	0	0	44
Teaching aid	0	0	2	1	1	10	14
TOTAL	44	35	36	28	24	22	189

NOTE: Chi-square values for all tables were significant at the 0.001 level.

computing; most Engineering users employed the computer to solve mathematical-type problems; Lincoln College users were typically involved in data analysis; nearly half of the external users were high school teachers responding on behalf of their classes.

The answers to questions B11, B12 and B13 told whether users had particular computer-related responsibilities. After the responses had been examined, we decided to create a new variable that counted the number of these questions answered "yes" for each user. Naturally these responsibilities were held by staff and external users more than by post-graduate and undergraduate students.

4.1.3 Skills and Experience

In the 1978 survey, the following measures of instruction and skill were used:

A4	Amount of formal instruction in computing
A5	Source of instruction in computing
A9	Knowledge of major language

The derivation of the last-named variable from the language data is described in Section 4.1.4. In the 1980 survey, there were the following measured:

B5	Years of computing experience
B6	Age
B7	Amount of formal instruction in computing
B8	Source of instruction in computing
B9	Highest level of mathematics studied
B10	Relative adequacy of maths skills
B14	Use of other computing facilities
B21.1	Knowledge of major lanugauge
B21.2	Knowledge of Work Flow Language
B21.3	Knowledge of CANDE

The raw data for question B5 showed the year of the respondent's first use of a computer. From these data a rough indication of the number of years of experience each user had with computers was derived using the formula:

Experience = 1981 - (year of first use of computers).

Considerable variation in the responses to some of these questions

was attributable to differences between the undergraduate students, most of whom were studying Computer Science, and other users. These students were younger, and had less computing experience but more formal instruction than other users. However, they had not studied mathematics to a significantly different extent; nor did they rate their mathematical or computing language skills higher or lower than other users.

Postgraduate and external users had, on average, more computing experience than the undergraduates; mean values for these groups were 5, 6 and 3 years, respectively. Staff had generally received little instruction in computing but had considerable computing experience - on average, 11 years. We hypothesized that these differences in background might pose problems for the providers of their computing services.

In general, the level of a user's knowledge of computing languages was not related to the user's age, experience or instruction in computing. The only significant relationship was a weak positive correlation between the amount of instruction received and skill with the user's major language or package. The value of this correlation for the 1978 survey was +0.25; for the 1980 survey it was +0.23.

The sources of the formal computing instruction received by users were various; (see the summaries for questions A5 and B8 in the Appendices). Generally, the source of the instruction for undergraduates was a university course. In both surveys, a small number of users explained that their principal source of practical instruction had been by informal means, such as assistance from research supervisors and peers, or by trial and error. These comments and the typically weak or insignificant correlations between the amount of instruction and skills suggest that formal instruction is not the sole source of computing skills, nor is it the most important for all users.

The relationships between the various measures of mathematical and computing language skills were similar for undergraduates and other users. Significant correlations for all respondents to the 1980 survey are shown below:

Skills, 1980		B9	B10	B21.1	B21.2
B9	Level of mathematics	*			
B10	Adequacy of maths	+.48	*		
B21.1	Major language knowledge	+.19	+.42	*	
B21.2	WFL knowledge	—	+.24	+.58	*
B21.3	CANDE knowledge	—	+.27	+.44	+.66

These associations indicated that mathematics is of some relevance to computing skills. Moreover, it appears that the adequacy of the user's mathematical skills is more important that the actual level of mathematics studied.

A number of analyses of variance were performed to determine whether the level of users' skills with computing languages, etc., varied between application or discipline categories. Significant results from the 1980 survey are shown in Tables 11 and 12. These results show that there existed considerable variation between application groups and disciplines in the levels of mathematics studied, but a less marked effect in the adequacy of mathematical skills. There was significant variation in knowledge of the Work Flow Language according to application, and significant variation in knowledge of CANDE with discipline. This last result shows that there was particularly high CANDE expertise in Science departments and this is indicative of high CANDE usage in those departments.

Table 11

Skills by Major Application

B2 MAJOR APPLICATION	NUMBER OF RESPONDENTS	B9 LEVEL OF MATHEMATICS	B10 ADEQUACY OF MATH. SKILL	NUMBER OF RESPONDENTS	B21.2 WFL KNOWLEDGE
Data analysis	66	2.56	3.50	64	2.44
Math.-type problems	56	3.16	4.20	52	2.60
Information proc.	9	2.44	3.44	9	1.67
Studying	44	3.02	4.07	44	2.84
Teaching	14	3.29	4.14	14	1.79
OVER ALL	189	2.89	3.88	183	2.49
STANDARD DEVIATION		0.67	1.00		1.03
F STATISTIC		10.855	5.178		4.902
PROBABILITY		< 0.001	< 0.001		< 0.001

Table 12

Skills by Discipline

DISCIPLINE	NUMBER OF RESPONDENTS	B9 LEVEL OF MATHEMATICS	B10 ADEQUACY OF MATH. SKILL	NUMBER OF RESPONDENTS	B21.3 CANDE KNOWLEDGE
Computer Science	44	3.02	4.09	44	2.23
Engineering	35	3.20	4.20	34	2.12
Sciences	36	2.81	3.83	36	2.75
Arts	28	2.68	3.75	27	1.93
Lincoln	25	2.40	3.32	22	2.05
External	23	3.13	3.87	23	1.57
OVER ALL	191	2.90	3.88	186	2.16
STANDARD DEVIATION		0.67	1.00		1.22
F STATISTIC		6.767	2.903		3.211
PROBABILITY		< 0.001	0.015		0.008

4.1.4 Mode and Language Use

Questions relating to mode and language use in the 1978 survey were:

A7 Program writing method
A8 Program writing purpose
A9 Use and knowledge of languages
A11 Mode of computer use

The large amount of data concerning language use and knowledge that was collected in this survey proved less useful than had been anticipated. This was because most users employed only one or two languages. Little use was made of these data other than the construction of new variables indicating the user's major language, the proportion of work done in that language, and the user's knowledge of it.

In the 1980 survey there were the following questions:

B19.1 Major language
B19.2 Proportion of work done in major language
B20.1 Second language
B20.2 Proportion of work done in second language
B22 Program writing method
B23 Program writing purpose

The distribution of responses for the principal language used are shown in Table 13. The apparent increase in use of COBOL arose from its use by undergraduate students in Computer Science. The majority of programmers continued to use FORTRAN or ALGOL. The most widely-used package was SPSS, according to the more-detailed 1980 survey results.

Further information about the user's mode of interaction was gained by the questions concerning program writing method and purpose. Cross-checking responses to these questions against those of language use revealed that many package users had answered the program writing questions. We concluded that these questions were inadequate for discriminating programming users from package users. Subsequently, we established this distinction according to the user's major language and, in cases where this datum was missing, by referring to his answers to other questions. Results of this categorization are shown in Table 14.

In both surveys, similar proportions of programmers to package users

Table 13

Major Language Used

A9 MAJOR LANGUAGE 1978	NUMBER OF RESPONSES		B19.1 MAJOR LANGUAGE 1980	NUMBER OF RESPONSES	
FORTRAN	89	(51%)	FORTRAN	78	(42%)
ALGOL	46	(27%)	ALGOL	37	(20%)
COBOL	3	(3%)	COBOL	19	(10%)
Assembler	2	(1%)	Other programming languages	8	(4%)
Packages	29	(17%)	Packages	43	(23%)
Missing data	13	---	Missing data	7	---
TOTAL	187	(100%)	TOTAL	192	(100%)

Table 14

Mode of interaction

MODE	1978 SURVEY		1980 SURVEY	
Programming user	149	(80%)	144	(76%)
Package user	38	(20%)	45	(24%)
Indirect user	-	-	3	-
TOTAL	187	(100%)	192	(100%)

were found in all status categories except the undergraduates. Undergraduates were generally involved in studying computing and this usually required program-writing assignments rather than package use.

There was significant variation in the mode employed by users in different disciplines and with different applications. The user's mode appeared most clearly dependent on his/her application, and this association is shown in Tables 15 and 16. The 1980 results show that the predominant use of packages is for data analysis; packages are also used for information processing applications and in certain mathematical problem-solving situations.

An important difference between programming and package users lay in their level of skills. In both surveys, package users rated their knowledge of their major language (package) lower, and had received less formal instruction in computing than programming users. Extra data collected in the 1980 survey showed that package users also rated their instruction in mathematics and their skills with mathematics and the system command languages (WFL and CANDE) lower.

4.1.5 Medium

Two questions from the 1978 survey concerning the user's medium of communication were:

A12 Usual medium of communication
A20 Output collection method

In addition, some information about the media used was gained by examining the responses to the batch and CANDE satisfaction questions (A21 and A22). Preceding these questions were instructions of the form: "Are you a batch user? If so, how satisfied are you with: ...". We considered any user answering one or more batch questions a batch user, and defined CANDE users similarly. The use of the two media is shown in Table 17.

Table 15

Mode by Major Work Type, 1978 Survey

A3.1 MAJOR WORKTYPE	A9 MODE		TOTAL
	PROGRAMMING USER	PACKAGE USER	
Number crunching	51	4	55
Package analysis	14	26	40
Data processing	30	6	36
Developing models	17	0	17
Teaching	6	2	8
Learning	31	0	31
TOTAL	149	38	187

Table 16

Mode by Major Application, 1980 Survey

B2 MAJOR APPLICATION	B19.1 MODE		TOTAL
	PROGRAMMING USER	PACKAGE USER	
Data analysis	36	27	63
Mathematical problems	45	11	56
Information processing	3	6	9
Studying computing	44	0	44
Teaching	13	1	14
TOTAL	141	45	186

NOTE: Chi-square statistics for both tables were significant at the 0.001 level.

Questions in the 1980 survey concerning media were:

B24 Proportion of work done via batch
B25 Usual batch job site

From the responses to question B24, the media employed by each user could be determined; the results are shown in Table 18. In addition to this indicator, the responses to the batch and CANDE satisfaction questions (B33 and B34) were used similarly to those in the 1978 survey.

Examining the results from both surveys, we found that nearly all users employed the batch medium. However, an increasing proportion of users also employed CANDE: 24% of the 1978 users answered CANDE questions, whereas 47% of the 1980 users did so, and 52% indicated directly that they used CANDE. (Cases with missing data were excluded from the calculations of these figures.) Differences in the results of the two surveys reflect the growth in the use of CANDE over the period 1978 to 1980.

It appeared that CANDE was used to about the same extent by users in the different status categories. Also, CANDE use did not vary significantly with the kind of work undertaken. However it did vary significantly between disciplines, as shown in Table 19. It was clear that a large proportion of Science users employed CANDE; by contrast, few external users did so. (Ten of them were teaching high school students who used the batch service somewhat indirectly.)

By considering together the medium and mode variables, we found that proportionately fewer package users than programming users employed CANDE. The 1978 survey indicated that 6% of package users and 26% of programming users employed CANDE. The corresponding proportions for the 1980 surveys were 38% and 55%; however, the Chi-square statistic for this cross-tabulation of medium against mode was not significant at the 0.01 level.

Those who used CANDE were significantly more highly skilled with

Table 17

Satisfaction questions answered, 1978 survey

QUESTIONS ANSWERED	NUMBER OF RESPONDENTS	
Batch only	138	(77%)
Batch and CANDE	39	(22%)
CANDE only	3	(2%)
Missing data	7	—
TOTAL	187	(100%)

Table 18

Media used, 1980 Survey

B24 MEDIA USED	NUMBER OF RESPONDENTS	
Batch only	86	(49%)
Batch and CANDE	83	(47%)
CANDE only	8	(5%)
Missing data	15	—
TOTAL	192	(100%)

Table 19

CANDE Use by Discipline, 1980 Survey

DISCIPLINE	B24 MEDIA USED		TOTAL
	BATCH ONLY	BATCH AND CANDE OR CANDE ONLY	
Computer Science	24	20	44
Engineering School	16	18	34
Sciences	8	26	34
Arts	13	12	25
Lincoln College	9	10	19
External	16	5	21
TOTAL	86	91	177

computing languages - not only with CANDE, as might be expected, but also with their own major language and the Work Flow Language. However, they were neither older nor more experienced, nor had they received more formal instruction in computing or mathematics than other users.

Having already established that programming users were more highly skilled than package users (see Section 4.1.4) and that proportionately more of them used CANDE, we checked the influence on skills of the interaction of the mode and medium variables. The results suggested that the most distinctive group comprised those programming users employing CANDE. They were generally more skilled than both batch-only programmers and package users employing CANDE.

Other questions regarding the user's medium of communication provided some interesting results. Certain undergraduate students were required to submit batch jobs via a Computer Science department courier service. Other users were free to use either the Computer Centre or the Engineering terminal. However, the convenience of location of these sites to the user's work place was obviously important: almost all Science and Arts users used the Computer Centre and nearly all Engineering School users used the Engineering batch terminal. Lincoln College users almost invariably used the Lincoln batch terminal because of their remoteness from the central site. External users generally used the Centre, perhaps because of the greater range of services available there.

4.1.6 Quantity of Use

Two measures of the quantity of use made of the service were employed in the 1978 survey:

A6 Average monthly computing expenditure
A13 Regularity of computing activity

In the 1980 survey four measures were employed:

B15 Average monthly computing expenditure
B16 Average frequency of use
B17 Regularity of computing activity
B18 Maximum period of disuse (dormancy)

Respondents were asked to estimate their expenditure in dollars, rather than to specify a range of values as was done in the first survey. Expenditure for external users was adjusted to equivalent internal rates, to compensate for the different charging scales.

There were significant correlations between all measures of usage. In the 1978 survey, the correlation between expenditure and regularity was +0.34. Correlations among the measures used in the 1980 survey are shown below:

Usage, 1980	B15	B16	B17
B15 Expenditure	*		
B16 Frequency	+.40	*	
B17 Regularity	+.44	+.68	*
B18 Dormancy	-.37	-.70	-.65

There was considerable diversity in the work patterns revealed by these questions. Tables 20 and 21 show the amount of use made by users in different status categories. A consistent pattern emerged: overall, staff tended to spend the most money but used the services least regularly; undergraduates spent the least yet they used the services quite regularly.

Since allocation of computing funds was largely a departmental matter, we expected some variation in expenditure to be explained by differences between departments. Some such differences were apparent in the analysis of variance which is shown in Table 22. The table shows particularly low expenditure for Computer Science users, nearly all of whom were undergraduates. Science and Engineering users appeared to be the highest spending groups.

Some variation in the amount of use of the system was related to the medium employed by users. In both surveys, we found that batch-and-CANDE

Table 20

Use by Status, 1978 Survey

A1 STATUS	A6 EXPENDITURE		A13 REGULARITY	
	NUMBER OF RESPONDENTS	MEAN SCORE	NUMBER OF RESPONDENTS	MEAN SCORE
Staff	63	2.79	68	2.94
Postgraduate	40	2.55	43	3.49
Undergraduate	46	1.54	49	3.59
External	24	2.17	26	2.96
OVER ALL	173	2.32	186	3.24
STANDARD DEVIATION		1.27		1.22
F STATISTIC		10.773		3.962
PROBABILITY		0.002		0.010

Table 21

Use by Status, 1980 Survey

B1 STATUS	B15 EXPENDITURE		B16 FREQUENCY	
	NUMBER OF RESPONDENTS	MEAN IN DOLLARS	NUMBER OF RESPONDENTS	MEAN SCORE
Staff	61	46.16	66	4.23
Postgraduate	35	36.60	36	4.89
Undergraduate	45	7.29	58	4.59
External	20	27.48	23	4.26
OVER ALL	161	31.02	183	4.48
STANDARD DEVIATION		52.39		1.28
F STATISTIC		5.325		2.487
PROBABILITY		0.002		0.062

Table 22

Expenditure by Discipline, 1980 Survey

DISCIPLINE	NUMBER OF RESPONDENTS	B15 MONTHLY EXPENDITURE ($)
Computer Science	40	8.58
Engineering	28	40.93
Sciences	30	56.07
Arts	23	29.87
Lincoln	23	29.87
External	17	26.44
OVER ALL	161	31.02
STANDARD DEVIATION		52.39
F STATISTIC		3.291
PROBABILITY		0.008

users spent more and used the system more than batch-only users, according to their scores on all measures of use. In particular, the high spending of Science users was related to the large proportion of users in this discipline using CANDE (see Section 4.1.5).

To a lesser extent, the amount of use made of the system was related to the users' mode of interaction. Package users were found to spend significantly less, and to use the system less frequently and less regularly. (Undergraduates were excluded from these comparisons because of their characteristic pattern of usage.)

There were a number of interesting associations between the amount of use made of the services and users' skills with computing languages: high use was associated with high skill. This is demonstrated by observations from both surveys. In the 1978 survey, correlations between users' knowledge of the major language and the two use variables, expenditure and regularity of use, were +0.26 and +0.33, respectively. Correlations between the measures of use and skill from the 1980 survey are shown below:

Usage and Skills, 1980	B15 Expenditure	B16 Frequency	B17 Regularity	B18 Dormancy
B21.1 Major Language knowledge	+.35	+.50	+.44	-.37
B21.2 WFL knowledge	+.36	+.52	+.51	-.50
B21.3 CANDE knowledge	+.41	+.41	+.41	-.44

(All coefficients were significant at the 0.001 level using a two-tailed test.)

Results described in Section 4.1.5 indicated that computing language skills varied significantly with mode and medium; we knew also that usage varied with mode and medium. Hence it was necessary to verify the

relationships between use and skills, controlling for the effects of medium and mode.

Correlations between knowledge of CANDE and the usage variables were non-significant for batch-only users, as expected. The relationships between use and skills were confirmed for all programming users; correlations were very similar to those shown in the table above. For package users, however, these relationships were generally weak or insignificant. A note-worthy exception was that, for package users in the 1980 survey, there was a moderate positive correlation (+0.49) between expenditure and knowledge of the user's major language (package).

We concluded that there exists a substantial relationship between computing language skills and quantity of use.

4.1.7 Use of Support Facilities

Questions in the 1978 survey concerning use of support facilities were:

A14	Use of Duty Programmer service
A15	Use of reference manuals
A16	Own Users' Guide
A17	Receive Newsletter
A18	Attendance at Users' Group meetings
A19	Input preparation method

In the 1980 survey the following questions were used:

B26	Input preparation method
B27	Use of Duty Programmer service
B28	Own Users' Guide
B29	Receive User Notes
B30	Receive Newsletter
B31	Use of documentation
B32	Attendance at Users' Group meetings.

From the answers to questions B28, B29 and B30, a new variable was created which showed how many of the three types of documentation were owned or received.

We will first consider the use of the information services (documentation and the duty programmer service), and then look at use of the data preparation service and the Users' Group.

Comparing figures from the two surveys, we found that very similar proportions of our samples owned the Users' Guide (54% for both surveys) and received the Newsletter (49%, 1978 and 44%, 1980). However, the 1980 survey showed that User Notes had made a substantial impact, reaching 40% of the sample.

Our next interest was in finding out whether all sectors of the population owned the documentation. Results from both surveys indicated that this was not the case. The predominant effect was that more documentation was held by the staff and external users than by the students.

Ownership of documentation was not significantly related to computing language skills, mode or medium. Neither was it related to the measures of amount of use of the system, expect for expenditure. We found that those who received each type of documentation spent significantly more than other users. (Undergraduates were excluded from these comparisons because of their known low expenditure and low documentation ownership.)

The use of documentation followed patterns more similar to those of the use of the duty programmer service than those of documentation ownership. The reader should notice that the questions used to ascertain documentation usage were not identical in the two surveys: question A15 referrred to "reference manuals", whereas question B31 used the more general term "documentation". These variables were significantly correlated with those concerning the amount of use of the duty programmer service; the correlation coefficients were +0.19 and +0.39 for the 1978 and 1980 surveys, respectively.

The 1978 survey showed no significant relationships between use of the two support services and the user's mode or medium. However, the 1980 survey showed that batch-and-CANDE users were found to use them more than batch-only users; also programming users used them more than package users.

We discovered certain positive correlations between the user's levels of computing skills and the quantity of use of the support services. However, these relationships were generally attributable to differences between the groups of users who employed different modes or media of interaction. There was one exception: knowledge of the user's major language was definitely related to documentation usage. Correlations from the 1978 and 1980 surveys were +0.26 and +0.43, respectively.

Usage of the support services and usage of the system were positively related. These relationships were generally consistent for users in the different medium and mode categories. Significant correlations between these measures for all non-undergraduate users in the 1978 survey are shown below:

Usage and Support, 1978	A15 Use of duty programmer service	A16 Use of reference manuals
A5 Expenditure	+.44	+.23
A13 Regularity	+.36	+.30

Similar results were obtained from the 1980 data:

Usage and Support, 1980	B27 Use of duty programmer service	B31 Use of documentation
B15 Expenditure	+.33	—
B16 Frequency	+.41	+.45
B17 Regularity	+.42	+.32
B18 Dormancy	-.38	-.38

In summary, usage of the documentation and the duty programmer service was positively related to system usage. Also documentation usage was related to the user's knowledge of his/her major language.

Questions A19 and B26 asked about the methods usually used for preparation of programs and data. Results showed that 51% of the 1978 sample and 59% of the 1980 sample usually used the professional data preparation services provided at the Computer Centre or at Lincoln College. Most other users indicated that they did their own keypunching.

This choice of input preparation method did not appear to be related to any considerations of status, skills, experience or amount of use of the system or other support services. Results from the 1978 survey showed that professional data preparation services were used by proportionately more programming than package users, and by more batch-and-Cande than batch-only users. However, this was not confirmed by the 1980 survey.

The Users' Group was set up as a means of communication between users and the Centre, but the proportion of users attending at least one meeting per year was low: 24% of the 1978 sample and 17% of the 1980 sample. Staff formed the main component of attenders, as can be seen from Tables 23 and 24. Compared with other staff in the 1980 sample, those who attended meetings had more responsibilities, were more skilled according to all 3 measures (B21.1, B21.2, B21.3), used the system more often and had shorter periods of disuse (B16 and B18). The mean monthly expenditure of attending staff was $69, which was substantially greater than the mean expenditure of $36 for other staff; however this difference was not statistically significant.

The cross-tabulation of attendance by discipline for the 1980 sample, shown in Table 25, suggested that the groups were not proportionally represented. The low attendance of Lincoln and external users can be explained by their remoteness from the site. Attendance appeared highest among Science users.

Users' Group attendance was not biased with respect to the mode of interaction, but it was with respect to medium: 21 out of 44 attenders

Table 23

Users' Group Attendance by Status, 1978 Survey

A1 Status	A18 Number of Meetings Attended Per Year		TOTAL
	Nil	1 or more	
Staff	44	25	69
Postgraduate	31	12	43
Undergraduate	45	4	49
External	22	4	26
TOTAL	142	45	187

Table 24

Users' Group Attendance by Status, 1980 Survey

B1 Status	B32 Number of Meetings Attended Per Year		TOTAL
	Nil	1 or more	
Staff	45	22	67
Postgraduate	37	3	40
Undergraduate	54	5	59
External	23	3	26
TOTAL	159	33	192

Table 25

Users' Group Attendance by Discipline, 1980 Survey

Discipline (SVC)	B32 Number of Meetings Attended Per Year		TOTAL
	Nil	1 or more	
Computer Science	37	7	44
Engineering	34	1	35
Science	25	11	36
Arts	21	8	29
Lincoln	21	4	25
External	21	2	23
TOTAL	159	33	192

NOTE: The Chi-square statistic probability for this table was 0.02.

in the 1978 survey and 27 out of 32 in the 1980 survey used both batch and CANDE.

In short, attendance at the Users' Group was not representative; attenders were more likely to be staff in Science departments who used CANDE, were more highly skilled and spent more than most other users. To some extent, their heavy involvement in computing explained their interest in representation and attendance. However this did not explain their feelings about the service, nor did it identify topics of particular concern to them.

4.1.8 Satisfaction

In the 1978 survey, users were asked 19 questions concerning their satisfaction with various aspects of the service. For the 1980 survey, some changes were made, bringing the total to 22. Unfortunately, a question regarding the fairness of the charging algorithm was omitted from the 1980 questionnaire. The distribution of responses and summary statistics for the satisfaction questions are shown in Tables 26 and 27.

Generally mean scores fell within the range of +0.1 to +0.7, indicating an overall slightly positive or "satisfied" response. The standard deviations for most distributions were between 0.8 and 1.1. One exception was the question regarding the Users' Group; in both surveys the standard deviation was only 0.58. This was explained by the typically "indifferent" response of the many non-attenders.

In Section 3.3 we described three methods for ranking the satisfaction variables so as to identify areas of particularly high or low satisfaction. The following comparison was achieved by ranking satisfaction questions from each survey according to each of the three methods and then measuring the degree of association between rankings using Spearman's rho statistic. The results for the 19 questions of the 1978 survey are shown in the upper diagonal of the matrix below; results from the 22 questions of the 1980 survey are in the lower diagonal.

TABLE 26

Summary of Responses to Satisfaction Questions, 1978 Survey

KEY

CATEGORY	SCORE
Highly dissatisfied	-2
Dissatisfied	-1
Indifferent - neither satisfied nor dissatisfied	0
Satisfied	1
Highly satisfied	2

QUESTION NUMBER AND SATISFACTION TOPIC		NUMBER OF RESPONSES BY CATEGORY -2	-1	0	1	2	TOTAL	SUMMARY STATISTICS MEAN	STD DEV.
BATCH QUESTIONS									
A21.1	Turnaround time	8	49	46	55	18	176	+0.15	1.08
A21.2	Hours of availability	8	38	44	50	34	174	+0.37	1.16
A21.3	Queue and priority structure	4	12	63	67	29	175	+0.60	0.92
A21.4	Advice of delays	9	28	77	34	24	172	+0.21	1.04
A21.5	Location of facilities	3	18	60	46	46	173	+0.66	1.04
CANDE QUESTIONS									
A22.1	Editing response time	0	7	9	20	4	40	+0.53	0.91
A22.2	Task execution time	3	9	18	8	4	42	+0.02	1.05
A22.3	Hours of availability	9	15	6	8	3	41	-0.46	1.25
A22.4	Range of facilities	3	7	8	15	8	41	+0.44	1.21
A22.5	Assistance during sessions	3	5	19	9	3	39	+0.10	1.00
GENERAL QUESTIONS									
A23	Centre response to problems	7	14	72	47	31	171	+0.47	1.01
A24	Duty Programmer service	7	22	68	49	20	166	+0.32	0.99
A25	Availability of staff	1	17	68	55	31	172	+0.57	0.92
A26	Data Preparation facilities	2	17	59	43	49	170	+0.71	1.03
A27	Quality of documentation	20	32	56	47	16	171	+0.04	1.15
A28	Provision for unusual requirements	3	6	83	39	27	158	+0.51	0.89
A29	Users' Group	3	10	123	7	5	148	+0.01	0.58
A30	Adequacy of funds	3	15	40	58	61	177	+0.90	1.03
A31	Fairness of charging algorithm	6	18	75	48	23	170	+0.38	0.97

NOTE: For the full text of questions, see Appendix A.

TABLE 27

Summary of Responses to Satisfaction Questions, 1980 Survey

KEY

CATEGORY	SCORE
Highly Dissatisfied	-2
Dissatisfied	-1
Indifferent - neither satisfied nor dissatisfied	0
Satisfied	1
Highly Satisfied	2

QUESTION NUMBER AND SATISFACTION TOPICS		NUMBER OF RESPONSES BY CATEGORY -2	-1	0	1	2	TOTAL	SUMMARY STATISTICS MEAN	STD DEV.
BATCH QUESTIONS									
B33.1	Turnaround time	16	54	32	54	7	163	-0.11	1.11
B33.2	Hours of availability	10	23	27	86	16	162	+0.46	1.05
B33.3	Job submission and collection procedures	13	16	41	77	15	162	+0.40	1.05
B33.4	Queue and priority structure	3	14	50	82	13	162	+0.54	0.84
B33.5	Location of facilities	1	13	38	80	29	161	+0.76	0.86
B33.6	Range of facilities	4	14	51	76	16	161	+0.53	0.88
CANDE QUESTIONS									
B34.1	Editing response time	3	22	16	33	5	79	+0.19	1.04
B34.2	Task execution time	4	25	20	26	5	80	+0.04	1.05
B34.3	Access to services	10	29	22	14	5	80	-0.31	1.10
B34.4	Task resource limits	6	20	26	22	5	79	0.00	1.05
B34.5	Assistance during sessions	6	22	37	11	1	77	-0.27	0.85
B34.6	Range of facilities	3	12	29	31	4	79	+0.27	0.92
GENERAL QUESTIONS									
B35.1	Data Preparation service	2	5	36	84	42	169	+0.94	0.83
B35.2	Adequacy of funds	9	22	21	83	42	177	+0.72	1.11
B35.3	Centre response to problems	2	9	74	63	21	169	+0.54	0.82
B35.4	Quality of documentation	12	30	53	68	9	172	+0.19	1.02
B35.5	Provision for unusual requirements	1	9	70	55	25	160	+0.59	0.84
B35.6	System availability	6	31	55	65	13	170	+0.28	0.97
B35.7	Duty Programmer service	2	9	67	68	20	166	+0.57	0.82
B35.8	Availability of staff	4	13	61	66	24	168	+0.55	0.91
B35.9	Diagnostics and messages	3	21	47	86	13	170	+0.50	0.87
B35.10	Users' Group	2	15	101	24	0	142	+0.04	0.58

NOTE: For the full text of questions, see Appendix B.

1980 \ 1978	1.	2.	3.
1. Mean Score	*	.63	.62
2. Index Value	.88	*	.98
3. Proportion dissatisfied	.89	.99	*

We concluded that the van der Hart index could easily be replaced by the more meaningful proportion dissatisfied measure, since the two were extremely high correlated. The lower correlations between these two measures and the mean score measure reflect major differences in their construction and utility. Although the mean score is useful for certain purposes, we decided to use the proportion dissatisfied measure to indicate areas of substantial dissatisfaction.

Several such areas that were identified by the 1978 survey are listed below.

QUESTION NUMBER AND SATISFACTION TOPIC	PROPORTION DISSATISFIED
A22.3 Hours of CANDE availability	59%
A21.1 Batch turnaround time	32%
A27 Quality of documentation	30%
A22.2 CANDE task execution time	29%
A21.2 Hours of batch availability	26%
A22.4 Range of CANDE facilities	24%

It is interesting to observe that several of the same critical areas emerged from the 1980 survey:

QUESTION NUMBER AND SATISFACTION TOPIC	PROPORTION DISSATISFIED
B34.3 Access to CANDE services	49%
B33.1 Batch turnaround time	43%
B34.5 Assistance during CANDE sessions	36%
B34.2 CANDE task execution time	36%
B34.4 CANDE task resource limits	33%
B34.1 CANDE editing response time	32%

All of these questions, with the exception of documentation in the first study, concerned operational aspects of the service. The results suggested that many users were considerably frustrated by the processing capability available to them. Also, we observed that nearly one third of all users were dissatisfied with the documentation in 1978.

The collection of satisfaction data concerning the same topics in the two surveys allowed some statistical comparisons that reflected changes in user satisfaction over the period 1978 to 1980. Student's t statistic was calculated for each of 16 pairs of matching questions; differences that were significant at the 0.05 level using a two-tailed text are shown below:

QUESTION NUMBERS 1978	1980	SATISFACTION TOPIC	MEAN SCORES 1978	1980	STUDENT'S t STATISTIC
A21.1	B33.1	Batch turnaround time	+0.14	-0.11	-2.17
A21.5	B34.5	Assistance during CANDE sessions	+0.10	-0.27	-2.15
A24	B35.7	Duty Programmer service	+0.32	+0.57	+2.64
A26	B34.1	Data Preparation service	+0.71	+0.94	+2.41

In certain other areas there were substantial but not statistically significant changes in user satisfaction: decreases for CANDE editing response time (A21.1, B34.1) and the adequacy of computing funds (A30, B35.2), and an increase for quality of documentation (A27, B35.4).

In the remainder of this section, we report the results of some analyses intended to test a number of hypotheses regarding the level of satisfaction of particular groups of users with specific services.

(a) Hypothesis: informational support was less satisfactory for package users than programming users. The criterion variables available concerned the quality of the available documentation (A27 and B35.4), adequacy of the duty programmer service (A24 and B35.7) and job/session diagnostics and error messages (B35.9). Comparisons of the mean scores of the two groups showed that package users were in fact *more* satisfied with the documentation than programming users (probabilities .003 and .042 for comparisons on questions A27 and B35.4 respectively). The two groups showed no significant differences on the other variables. Consequently the hypothesis was rejected.

(b) Hypothesis: use of informational support services was more satisfactory for skilled users. The measures of skill used in the 1978 survey concerned knowledge of the user's major language or package, and the amount of formal instruction in computing. There were no significant correlations between these variables and satisfaction with quality of the available documentation or adequacy of the duty programmer service. From the 1980 survey there were additional measures available, concerning skills with the Work Flow Language, CANDE and mathematics, and satisfaction with diagnostics and error messages. The only significant correlation between the five skills variables (questions B9, B10, B21.1 to B21.3) and the three satisfaction variables (B35.4, B35.7, B35.9) was a weak negative correlation (-0.23) between the level of mathematics studied and satisfaction with the documentation.

Clearly there was no evidence to support the hypothesis. We concluded that however the manner of use of informational services varies with expertise, it shows no direct or simple effect on user satisfaction with those services.

(c) Hypothesis: the dissatisfaction with documentation is general; that is, it is not particularly evident in any sector of the population. First, we have shown that programming users were less satisfied than package users, particularly at the time of the first survey. Second, a significant amount of the variation in satisfaction with the documentation in the first survey was attributable to differences between status categories: the mean score for staff was low (-0.40), while that for external users was high (+0.68). However, the F statistic for an equivalent analysis of variance conducted using 1980 data was not significant. We concluded that the dissatisfaction with documentation observed in the 1978 survey was most marked among programming users and staff. Satisfaction with documentation in the 1980 survey was slightly higher and did not show such obvious patterns.

(d) Hypothesis: the satisfaction levels of users who attend Users' Group meetings differ from those of other users. Comparisons from the 1978 survey showed the following differences: attenders were less satisfied with the batch hours, the queue and priority structure, the quality of the documentation, and the fairness of the charging algorithm, but more satisfied with the data preparation facilities.

Results from the 1980 survey showed a somewhat different pattern: attenders were less satisfied with the response time for execution of CANDE tasks and access to CANDE services, but more satisfied with the data preparation service and the availability of staff.

The mean score for attenders with the Users' Group itself as a medium for communicating their needs was -0.20 in 1978 and +0.21 in 1980. Not only had the range of topics that particularly concerned attenders

changed, but their overall satisfaction with the Users' Group itself was significantly higher.

(e) Hypothesis: users of different status and from different departments do not differ in their satisfaction with the adequacy of computing funds provided by their department.

Direct comparisons showed that undergraduates were significantly less satisfied with funds than other users. This was the only apparent source of variation in satisfaction with funds.

Other users were quite satisfied: their mean scores were +1.08 and +1.02 in the 1978 and 1980 surveys, respectively. These levels of satisfaction did not vary with status, discipline, mode or medium in either survey.

4.2 THE EFFECTIVENESS MEASURES

The questionnaire surveys conducted in 1978 and 1980 provided two data bases containing user and use characteristics and user satisfaction data, as reviewed in the previous section of this chapter. Using methods which were described in Chapter 3, we sought factors underlying the users' satisfaction responses. Two factor analyses were carried out for each data base: a batch analysis and a CANDE (interactive) analysis. Generally, the factors which were exposed described components of the users' satisfaction which we were able to identify and characterize.

The results of the four analyses are discussed below. The first analysis is presented in detail, in order to provide the reader with a firm understanding of the techniques which were used throughout. The four sets of results are compared in Section 4.2.5.

4.2.1 Batch Analysis, 1978

The analysis of the responses of the 175 users of the batch services in 1978 to the batch and general satisfaction questions (A21.1 to A21.5 and A23 to A31) generated four factors. The satisfaction variables most heavily loaded on these factors are shown in Table 28.

By considering the nature of the satisfaction topics substantially associated with each factor, and those topics not associated with it, it was possible to identify and label the underlying concept involved. The variables highly loaded on the first factor dealt with the support given to users by Computer Centre staff. Of all the variables in the analysis, these in particular concerned the personal interaction of users and staff, and this factor was labelled 'PEOPLE'.

This result suggests that there is a satisfaction dimension which underlies all these variables, that is, a factor concerning the user's satisfaction with his interaction with the staff which is manifested in his attitude to the duty programmer service, the operators, etc.

Table 28

Structure of the Batch Factors, 1978 Survey

FACTOR	LABEL AND DESCRIPTION	VARIABLE	LOADING
ONE	PEOPLE User-staff interaction	A23 Centre Response to problems	.69
		A24 Duty Programmer service	.63
		A28 Provision for unusual requirements	.63
		A25 Availability of staff	.60
TWO	BATCH	A21.2 Batch hours of availability	.68
		A21.1 Batch turnaround time	.56
		A21.4 Advice of batch delays	.45
		A21.3 Batch queue and priority structure	.43
		A21.5 Location of batch facilities	.43
THREE	FAIRNESS	A31 Fairness of the charging algorithm	.84
		A21.3 Batch queue and priority structure	.43
		A23 Centre response to problems	.27
		A29 Users' Group	.26
FOUR	FUNDS	A30 Adequacy of computing funds	.68
		A31 Fairness of the charging algorithm	.27

NOTE: For the complete factor pattern matrix see Appendix D.

Moreover, the PEOPLE factor accounted for the greatest proportion of the variance in the satisfaction variables that was explained by this analysis. (This is demonstrated below.) To some extent, the proportion of variance explained by each factor of any analysis depends on the number of highly inter-correlated variables included in the analysis, and the methods used. However, after considering the range and nature of the variables present, we concluded that the PEOPLE factor was of major importance.

The second factor was substantially related to all five questions on the batch service. Clearly this factor concerned the users' satisfaction with the operational aspects of the service; hence it was titled 'BATCH'. The third factor was labelled 'FAIRNESS'. The variable most highly loaded on this factor concerned the fairness of the charging algorithm; the other variables associated with it suggested other aspects of the service or the way in which the Centre allocated its resources or handled problems about which users might have some feelings of fairness. The fourth factor was related to the users' satisfaction with the provision of computing funds and the charging algorithm. Although funds are provided by user departments, and not by the Centre, this FUNDS factor is a matter of some importance to the users' satisfaction.

The relative importance of the factors and the effectiveness of the Centre in those areas are shown below.

FACTOR	PROPORTION OF VARIANCE	EFFECTIVENESS RATING
PEOPLE	39%	0.47
BATCH	30%	0.31
FAIRNESS	19%	0.15
FUNDS	12%	0.51

NOTE: Figures in the second column indicate the proportion of the variance explained by the analysis attributable to each factor. They were calculated from the eigenvalues of the factors, which are shown in Appendix D.

The figures show that, although the PEOPLE factor was the major factor, overall user satisfaction with it was high, as it was for the less important FUNDS factor. Users were evidently less satisfied with the batch service and those aspects of the service concerning its fairness.

We now turn to look at the relationships between the factor scores generated to represent the user's level of satisfaction with these dimensions and the user and use characteristics reviewed in Section 4.1.

We found interesting variations in the level of satisfaction of groups of different status, and groups of different major work types. Tables 29 and 30 show analyses of the variance attributed to these differences. We observe that the satisfaction levels of external users were generally high. By comparison, the satisfaction of the undergraduates was much lower on PEOPLE, BATCH, and particularly, FUNDS. However, the undergraduates did not score lower on the FAIRNESS factor. We suggest that the undergraduates, who have less computing experience, accept the rules of the games at least as easily as other groups. Staff scored highly on the FUNDS factor, but lowest on the BATCH and FAIRNESS factors.

Considering the analysis by major work type in Table 30, we find a familiar undergraduate pattern for the "Learning programming" group: low scores on PEOPLE, BATCH, and particularly FUNDS.
Package users appeared satisfied, as did users with data processing applications. Those users developing computer models or number crunching were satisfied with the PEOPLE and FUNDS factors, but scored low on the BATCH and FAIRNESS factors.

There were no substantial associations between user's skills and their satisfaction. The only significant result from this area was a weak negative correlation between knowledge of the user's major language and the BATCH factor scores ($r = -0.22$). This suggested that the more skilled users were less satisfied with the batch services.

Table 29

1978 Batch Factor Scores by Status

A1 STATUS	NUMBER OF RESPONDENTS	PEOPLE	BATCH	FAIRNESS	FUNDS
Staff	58	.36	.11	.11	.79
Postgraduate	36	.69	.42	.16	.59
Undergraduate	42	.17	.17	.31	.10
External	23	.91	.69	.26	.43
OVER ALL	159	.46	.28	.16	.51
STANDARD DEVIATION		0.84	0.81	0.88	0.76
F STATISTIC		5.477	3.585	1.073	7.753
PROBABILITY		0.001	0.015	N.S.	< 0.001

Table 30

1978 Batch Factor Scores by Major Work Type

A31.1 MAJOR WORK TYPE	NUMBER OF RESPONDENTS	PEOPLE	BATCH	FAIRNESS	FUNDS
Number crunching	49	.50	.17	-.13	.62
Package use	31	.74	.57	.43	.49
Data processing	32	.42	.30	.39	.73
Developing models	16	.40	-.05	-.01	.86
Teaching	6	.91	1.22	.25	.18
Learning programming	25	.04	.09	.18	-.12
OVER ALL	159	.46	.28	.16	.51
STANDARD DEVIATION		0.84	0.81	0.88	0.76
F STATISTICS		2.474	3.692	2.287	5.866
PROBABILITY		0.035	0.004	0.049	< 0.001

Considering the mode of interaction employed, we found that package users were more satisfied than programming users with the BATCH and FAIRNESS factors, but did not differ on the other factors. Furthermore, there was an interesting association between the nature of the software written or used and the BATCH factor. Question A11 defined four categories of interaction; for these categories, see question 11 of Appendix A. The mean scores for users in the four groups were, in order, .46, .48, .30 and -.35. These figures suggest that the batch service was less satisfactory for those users employing a complex software mode.

All users in the analysis used batch services; however, some also used CANDE. Users whose usual medium was CANDE scored significantly higher on the PEOPLE factor, and lower on the FAIRNESS factor than other users. Evidently, their interaction with the staff was satisfactory, but they were more concerned with the way the Centre, as an organization, allocated its resources.

There were some associations between the measures of use and the factor scores. Excluding the undergraduates, we found that expenditure was negatively correlated with the BATCH and FAIRNESS factors (-0.30 and -0.23, respectively) but not associated with the other factors. This suggested that the concerns of the big spenders were the operational aspects of the batch service and the fairness with which the resource was allocated. A positive correlation between the regularity of use and the PEOPLE factor ($r = +0.27$) lead us to believe that user-staff interaction is more satisfactory for regular users.

The only significant associations between use of support variables and factor scores concerned attendance at Users' Group meetings. Attenders were significantly less satisfied with the BATCH and FAIRNESS factors, but did not differ from non-attenders on the other factors. As was established in Section 4.1.7, attenders on average spent more than other users, and so these associations tie in with those regarding

expenditure reported above.

4.2.2 CANDE Analysis, 1978

This analysis involved the responses of 41 CANDE users to questions A22.1 to A22.5 and A23 to A31. Five factors were exposed, and these are summarised in Table 32.

The first factor was related to the question about funding and a number of others about staff support. The PEOPLE factor was similar to that of the batch analysis, described previously, except that for CANDE users the variable "Adequacy of computing funds" was most closely associated with it. The presence of this variable in a factor dominated by questions concerning user-staff relationships required explanation. It appeared that the aspect of the question of funds that we were dealing with concerned the feeling that users had about the process within their own departments through which they must apply for funds and justify expenditure. The association of the funds variable with the others suggested that there was an underlying factor involving the user's feeling towards all those people he must deal with in the course of using computing services.

The second factor involved the duty programmer service and the range and availability of CANDE services. Although the definition of this factor was not entirely clear, this factor was though to reflect the feelings of CANDE users towards certain TOOLS available to them.

The factor CANDE involved specific questions about operational aspects of the interactive service: the ease of obtaining assistance during a breakdown, and the task execution and editing response times.

The HELP factor concerned certain informational and operational support services and, in particular, the quality of the documentation.

The FAIRNESS factor had certain aspects in common with the batch FAIRNESS factor: the fairness of the charging algorithm, the response of the Centre to users' problems, and the Users' Group as a medium of

Table 31

Structure of the CANDE Factors, 1978 Survey

FACTOR	LABEL AND DESCRIPTION	VARIABLE	LOADING
ONE	PEOPLE User-staff interaction and funds	A30 Adequacy of computing funds	.89
		A25 Availability of staff	.66
		A28 Provision for unusual requirements	.53
		A24 Duty programmer service	.43
		A23 Centre response to problems	.43
TWO	TOOLS	A24 Duty Programmer service	.69
		A22.4 Range of CANDE facilities	.65
		A22.3 CANDE hours of availability	.61
		A25 Availability of staff	.39
THREE	CANDE	A22.5 Assistance during CANDE sessions	.87
		A22.2 CANDE task execution time	.73
		A22.1 CANDE editing response time	.44
FOUR	HELP Informational and operational support	A27 Quality of documentation	.88
		A28 Provision for unusual requirements	.45
		A23 Centre response to problems	.42
		A25 Availability of staff	.42
		A24 Duty Programmer service	.30
FIVE	FAIRNESS	A31 Fairness of the charging algorithm	.58
		A23 Centre response to problems	.44
		A28 Provision for unusual requirements	.38
		A29 Users' Group	.38

NOTE: For the complete factor pattern matrix see Appendix D.

communication.

The relative importance of these factors and the Centre's effectiveness in each area are shown below:

FACTOR	PROPORTION OF VARIANCE	EFFECTIVENESS RATING
PEOPLE	24%	0.73
TOOLS	23%	0.15
CANDE	20%	0.04
HELP	20%	-0.03
FAIRNESS	13%	0.36

The figures show that while the satisfaction of users was high with the PEOPLE factor, it was much lower, i.e. nearer "indifferent", for the TOOLS, CANDE and HELP factors. This indicates that more attention was necessary to provide the operational facilities and support required for CANDE users.

We now look at the relationships between the user and use characteristics and the CANDE factor scores.

The small number of undergraduate CANDE users scored significantly lower on the PEOPLE factor (as was the case in the batch analysis), but did not differ on the other factors. The significant relationships between the factor scores and the users' work type are shown below.

A3.1 MAJOR WORK TYPE	NUMBER OF RESPONDENTS	PEOPLE	CANDE
Number crunching	12	1.17	.49
Package use	5	1.12	-.29
Data processing	9	0.21	.10
Developing models	8	1.05	-.43
Teaching	1	0.16	2.08
Learning	4	-0.61	-.52
OVER ALL	39	0.71	0.04
STANDARD DEVIATION		0.93	0.93
F STATISTIC		4.745	2.872
PROBABILITY		0.002	0.029

Although the number of users in some groups are low, the three largest groups show differences in their levels of satisfaction that could be attributed to the way in which their different needs were being met, or perhaps not being met. For instance, those users developing computer models showed above-average scores on the PEOPLE factor, but distinct dissatisfaction with the CANDE service.

The only significant relationships between factor scores and skills variables were moderate negative correlations between knowledge of the users' major language and the TOOLS and CANDE factors (-0.36 and -0.37, respectively).

Our only observation regarding the mode variables was, that of the 41 users, only two were package users; clearly, programming users had CANDE all to themselves in 1978.

The only result concerning medium was that, of all the CANDE users, those whose usual medium it was, scored more highly on the PEOPLE factor than those whose usual medium was batch.

Between the measures of use and the factor scores there were two significant correlations. Expenditure was positively related to the PEOPLE factor (r = +0.50) and regularity of use was positively related to the HELP factor (r = +0.40).

Use of the duty programmer service was related only to the FAIRNESS factor. Between these two measures there was a moderate positive correlation (r = +0.49) for which no explanation was found.

Although Users' Group attenders differed from non-attenders on their scores on certain batch factors, they did not differ signficantly on their scores on any of the CANDE factors.

4.2.3 Batch Analysis, 1980

The batch analysis for the 1980 survey involved the responses of 160 batch users to questions B33.1 to B33.6 and B35.1 to B35.10. Five factors were constructed and they are summarised in Table 32.

The PEOPLE factor involved the various user-staff interaction aspects of the service as had the major factors of the other factor analyses. The second factor concerned those aspects which might constrain ACCESS of the batch user to the power of the machine: the batch job submission and collection procedures, turnaround time and the adequacy of funds. The third factor cannot be so easily characterized, but it is to do with the user's feelings towards the BATCH service, the way it is provided, and the Users' Group as a medium of communication. The BATCH and ACCESS factors appear to differ in the source of the user's feelings about them: the ACCESS factor concerns the batch job procedures and computing funds, which may be determined largely by the user's status, department and location, whereas the BATCH topics concern the Centre directly, and the way it provides the batch service.

The HELP factor principally involved satisfaction topics relating to the informational support provided to the user: the documentation,

Table 32

Structure of the Batch Factors, 1980 Survey

FACTOR	LABEL AND DESCRIPTION	VARIABLE	LOADING
ONE	PEOPLE User-staff interaction	B35.8 Availability of staff	.76
		B35.7 Duty Programmer service	.56
		B35.5 Provision for unusual requirements	.55
		B35.3 Centre response to problems	.49
		B35.1 Data Preparation service	.45
TWO	ACCESS Access to machine power	B33.3 Batch job procedures	.87
		B33.1 Batch turnaround time	.62
		B35.2 Adequacy of computing funds	.44
		B35.5 Provision for unusual requirements	.34
THREE	BATCH Batch operations and Users' Group	B33.1 Batch turnaround time	.62
		B33.2 Batch hours of availability	.52
		B35.10 Users' Group	.48
		B35.3 Centre response to problems	.33
		B33.4 Batch queue and priority structure	.30
FOUR	HELP Informational support	B35.4 Quality of documentation	.61
		B35.9 Diagnostics and error messages	.49
		B33.6 Range of batch facilities	.36
		B35.7 Duty Programmer service	.32
FIVE	LOCATION	B35.5 Location of batch facilities	.82
		B33.6 Range of batch facilities	.37
		B33.3 Batch job procedures	.24

NOTE: For the complete factor pattern matrix see Appendix D.

diagnostics and error messages, and the duty programmer service. The contribution of question B33.6, about the range of batch facilities, is unexplained.

The fifth factor was principally associated with the LOCATION of the batch facilities, and also with the range of facilities and the way in which they were made available.

The relative importance of each factor and the Centre's effectiveness in each area are shown below:

FACTOR	PROPORTION OF VARIANCE	EFFECTIVENESS RATING
PEOPLE	28%	0.87
ACCESS	22%	0.08
BATCH	19%	0.02
HELP	17%	0.20
LOCATION	14%	0.81

These figures show high satisfaction with the important PEOPLE factor. However, ratings for the ACCESS and BATCH factors suggest that the operational aspects of the service provided to users are much less adequate. The rating for the HELP factor is also low.

The association between the factor scores and status is shown in Table 33. The levels of satisfaction of external users tended to be above average, as was generally found to be true in the 1978 batch analysis. Undergraduates were clearly dissatisfied with their ACCESS and the BATCH service available to them, which in many cases was via a courier service. Staff were relatively well-satisfied with most factors, while postgraduates were dissatisifed with the BATCH service.

Since the user's application was somewhat dependent on his status (see Section 4.1.2), certain apparent associations between application and satisfaction reflected only the patterns described above. However

Table 33

1980 Batch Factor Scores by Status

B1 STATUS	NUMBER OF RESPONDENTS	PEOPLE	ACCESS	BATCH	HELP	LOCATION
Staff	56	1.01	0.35	0.15	0.17	0.74
Postgrad.	32	0.76	0.17	-0.29	0.07	0.95
Undergrad.	36	0.55	-0.64	-0.15	0.23	0.84
External	22	1.30	0.52	0.38	0.38	0.87
OVER ALL	146	0.89	0.10	0.02	0.20	0.83
STANDARD DEVIATION		0.83	0.90	0.77	0.76	0.81
F STATISTIC		4.824	14.71	4.746	0.778	0.478
PROBABILITY		0.003	<0.001	0.004	N.S.	N.S.

Table 34

1980 Batch Factor Scores by Discipline

DISCIPLINE	NUMBER OF RESPONDENTS	PEOPLE	ACCESS	BATCH	HELP	LOCATION
Computer Science	33	0.52	-0.64	-0.04	0.10	0.82
Engineering	27	0.64	0.22	-0.37	-0.13	1.31
Sciences	27	1.25	0.32	0.03	0.40	0.51
Arts	23	1.06	0.05	0.15	0.20	0.73
Lincoln	17	0.81	0.56	0.06	0.33	0.78
External	19	1.21	0.54	0.44	0.42	0.87
OVER ALL	146	0.89	0.10	0.02	0.20	0.83
STANDARD DEVIATION		0.83	0.90	0.77	0.76	0.81
F STATISTIC		3.917	8.404	2.785	2.013	3.280
PROBABILITY		0.002	<0.001	0.020	N.S.	0.008

different patterns are exhibited in the associations between discipline and satisfaction, as shown in Table 34. Engineering users were highly satisfied with the location of a batch terminal within the Engineering School, but were dissatisfied with the BATCH service itself. Science users scored highly on the PEOPLE factor but were evidently less satisfied with the location of facilities than other groups.

The experience of using other computer systems had some influence on user satisfaction. Those with previous experience of services in other places scored particularly highly on the PEOPLE factor, while those with current access to departmental equipment scored more highly on the ACCESS factor than other users.

The level of skill of users with their major language was to a small extent related to their scores on the PEOPLE and BATCH factors: there was a positive correlation ($r = +0.27$) with PEOPLE and a small negative correlation ($r = -0.19$) with BATCH. A number of other relationships between skills variables and the factor scores were attributable to differences between undergraduates and other users.

Package users were significantly more satisfied with the ACCESS and BATCH factors than programming users. We believe that the package users had lower needs in these operational areas, and were less concerned about them.

Medium also influenced satisfaction. Courier users, who were all undergraduates, scored low on the PEOPLE, ACCESS and BATCH factors. Those users whose usual batch access was via the Engineering terminal scored surprisingly low on the BATCH factor. We believe that this was partly due to the high requirements of the work generally undertaken by Engineering users and partly due to the close contact with the system that the terminal allowed. Consequently, these users were highly dependent on those components of the BATCH factor, such as turnaround time and hours. A poor or highly variable service would adversely

affect them more than other users.

Lincoln users scored highly on the ACCESS factor. This too was surprising, considering the remoteness of the site. Batch users whose usual medium was CANDE were significantly more satisfied with their ACCESS than other batch users.

There were interesting relationships between the measures of use and factor scores. The only significant relationships were negative correlations between expenditure, frequency and regularity of use and the BATCH factor (-0.27, -0.38 and -0.22, respectively, calculated excluding undergraduates). These results suggest that the batch service was less satisfactory for those who used it most, or alternatively that the quality of the service was more important to these users.

Some support usage variables were positively related to the PEOPLE factor. There were positive correlations with the amount of use made of the duty programmer service and with the amount of documentation owned (+0.45 and +0.25, respectively, calculated excluding undergraduates). Attenders at the Users' Group differed from non-attenders in that they scored more highly on the PEOPLE factor; however, their satisfaction with the other aspects of the service did not differ. No further explanation of these results was gained by data analysis; it was necessary to interview users and seek explanations directly.

4.2.4 CANDE Analysis, 1980

For this analysis, the responses of 78 CANDE users to questions B34.1 to B34.6 and B35.1 to B35.10 were used. Table 35 summarises the factors which were produced.

The PEOPLE factor was associated with satisfaction topics involving user-staff interaction, including "Assistance during CANDE sessions" and the data preparation service. The ACCESS factor concerned operational

Table 35

Structure of the CANDE Factors, 1980 Survey

FACTOR	LABEL AND DESCRIPTION	VARIABLE	LOADING
ONE	PEOPLE User-staff interaction	B35.8 Availability of staff	.78
		B34.5 Assistance during CANDE sessions	.64
		B35.1 Data Preparation service	.57
TWO	ACCESS Access to machine power	B34.2 CANDE task execution time	.94
		B34.1 CANDE editing response time	.74
		B34.3 Access to CANDE services	.32
		B34.4 CANDE task resource limits	.28
THREE	PROBLEMS Operational support	B35.3 Centre response to problems	.68
		B35.5 Provision for unusual requirements	.61
		B35.6 Advice of system availability	.53
		B35.8 Availability of staff	.47
		B35.7 Duty Programmer service	.37
FOUR	HELP Informational support	B35.4 Quality of documentation	.73
		B35.9 Diagnostics and error messages	.46
		B35.7 Duty Programmer service	.33
FIVE	TOOLS	B34.6 Range of CANDE facilities	.70
		B34.3 Access to CANDE services	.51
		B35.8 Availability of staff	-.29
SIX	USERS' GROUP	B35.10 Users' Group	.63
		B35.3 Centre response to problems	.36
		B34.3 Access to CANDE services	.33

NOTE: For the complete factor pattern matrix see Appendix D.

aspects of the interactive service (task execution and editing response times and task resource limits) and access to services. The PROBLEMS factor referred to various aspects of the operational support provided to users. It also had substantial loadings on the questions about the availability of staff and the duty programmer service; in this respect it resembled the PEOPLE factor.

The HELP factor was quite clearly defined. The TOOLS factors concerned the range and availability of CANDE services; in addition, question B35.8, about the availability of staff, was negatively loaded on this factor. This does not mean that B35.8 was negatively correlated with the other two variables; in fact, neither correlation was significant. Rather it implies that, at least mathematically, there exists a factor which positively influences the first two variables and negatively influences the third (to a small extent). After some grappling with the semantic implications for this, the source of this influence remained a mystery.

The final factor concerned the Users' Group and certain topics that intuitively appeared related.

The relative importance of these factors and the Centre's effectiveness in each area are shown below:

FACTOR	PROPORTION OF VARIANCE	EFFECTIVENESS RATING
PEOPLE	23%	0.44
ACCESS	21%	0.06
PROBLEMS	20%	0.71
HELP	13%	0.13
TOOLS	13%	0.00
USERS' GROUP	10%	-0.03

The figures show that the PROBLEMS of CANDE users were handled adequately but that user satisfaction with the availability of staff and the ease of obtaining assistance during a session, etc. (the PEOPLE factor) was not so high. Low ratings for the ACCESS and TOOLS factors indicated the low effectiveness of the CANDE service. The rating for the HELP factor was slightly positive, and similar to that of the 1980 batch HELP factor, but somewhat higher than the 1978 CANDE HELP factor. The USERS' GROUP rating was negative and this was cause for some concern.

Most of the apparent relationships between factor scores and the status and skills variables were the result of differences between undergraduates and other users: the undergraduates were less satisfied with the PEOPLE and PROBLEMS factors. However, there were confirmed negative correlations between satisfaction with the ACCESS factor and knowledge of the user's major language and CANDE (-0.28 and -0.35, respectively). The use and experience of other computer systems had some influence: users with previous experience of other services scored particularly highly on the similar PEOPLE and PROBLEMS factors.

In contrast with the other analyses, we found no associations between factor scores and the mode, medium or quantity of use variables.

However, use of support services had some influence. The PEOPLE factor was positively correlated with use of the duty programmer service and ownership of documentation (+0.33 and +0.32). The PROBLEMS factor was correlated with use of the duty programmer service and use of the documentation (+0.35 and +0.39). As in other anslyses, attenders at the Users' Group were more satisfied on the PEOPLE factor than non-attenders.

4.2.5 Comparison of Factor Structures

The comparison of structures obtained through the use of factor analysis in other fields has lead to the identification and cataloguing of a large number of psychological factors (see Cattell, 1978, p544). It is possible that in the field of man-computer interaction, consistent patterns in the satisfaction responses of particular categories of users may be recognized. In this regard, factor analysis in the present field is at an early, experimental stage. However, the factor structures described in the previous sections show certain consistencies.

One of the most interesting results was the predominance of user-staff interaction factors in all analyses. The structure of the PEOPLE factors was consistent, except for the inclusion of the funds variable in the PEOPLE factor of the 1978 CANDE analysis and the variable concerning assistance during sessions in that of the 1980 CANDE analysis.

It was also interesting to find clearly-defined FAIRNESS factors in the 1978 analyses. Because a question about the fairness of the charging algorithm was left out of the 1980 questionnaire, these factors were not reproduced in the 1980 analyses. However, the BATCH factor of the 1980 batch analysis, and the USERS' GROUP factor of the 1980 CANDE analysis, showed similarities to the FAIRNESS factors of the corresponding 1978 analyses.

Although there were other consistent patterns, the introduction of new variables in the 1980 analysis upset this consistency to some extent. The new question regarding job/session diagnostics and messages contributed to defining the informational support factors which we labelled 'HELP' in the two 1980 analyses. The new question regarding batch job submission and collection procedures helped to define the ACCESS factor of the 1980 batch analysis.

Certain overlap in the satisfaction topics substantially associated with each factor of an analysis was evident. For instance, the PEOPLE

and HELP factors of the 1978 CANDE analysis had four moderately-loaded variables in common. In terms of the factor model, this meant that those common variables were influenced by more than one underlying factor. That is, the questions measured user satisfaction with aspects of two or more fundamental attitudes.

An example of this was the question concerning the response of the Computer Centre to users' problems (A23 and B35.3). This variable was moderately loaded on 9 out of the 20 factors exposed by the analyses. After examining these factors, we can say that the question tapped user feelings about the Centre response to operational problems, the fairness with which the Centre conducts its business, the Users' Group, and the whole user-staff interaction.

We believe that the selection of satisfaction topics should be guided by these results in order to clearly distinguish these satisfaction factors. This process of factor identification depends greatly on careful experimental design, as detailed by Cattell (1978, p493-500).

4.3 THE INTERVIEWS

In total, 42 users were interviewed. These users gave their time freely; they were generally frank and very helpful, and for their contribution we are grateful. The results were useful on two levels:

First, questions in detail about use of the services and the user's feelings about them helped to explain the causes and effects of the individual's satisfaction. Users had been selected according to the levels of satisfaction shown by their factor scores, and there was generally a close correspondence between what one would expect from these scores and the feelings users expressed during the interviews.

Second, the interviews provided practical validation and explanation for the results of our data analysis. They indicated ways in which the services might be improved and also those aspects of the service which were good already and should be preserved.

We now discuss the bias inherent in selection of interview subjects and present four case studies. These are intended to illustrate the diversity of user experiences and attitudes, and to demonstrate how the interviews yielded useful information. The findings from all the interviews are summarised in Section 4.3.5.

In the 1980 survey, the willingness of users to be interviewed had to be coded, firstly to ease selection and secondly to allow some comparisons which are reported below.

Of the 192 respondents, 125 or 65% indicated their willingness to be interviewed. The representation of undergraduates within this group was low; less than one half provided contact information. Of the 133 non-graduates, the 99 prospective interviewees differed from other respondents in only the following respects: they were more skilled with computing languages according to all three measures (B21.1, B21.2 and B21.3) and they spent more computing funds. We concluded that this bias, like the questionnaire response bias, tended to include the more involved users in our sample.

4.3.1 Case Study I

This inteview subject, whom we shall refer to as R, was selected on the basis of his scores on the 1980 CANDE factors. His scores were as follows:

FACTOR	SCORE	QUARTILE
PEOPLE	+1.23	4
ACCESS	+0.28	3
PROBLEMS	+0.06	2
HELP	+0.58	3
TOOLS	+0.11	2
USERS' GROUP	-1.17	1

R was a lecturer in Chemistry, and heavily committed to use of the Burroughs system. His questionnaire responses indicated that he had considerable computing experience and expertise, though only a short period of formal instruction in computing.

R's major application was theoretical research in quantum chemistry; this required the development of a series of FORTRAN programs. His work pattern for this application required several sequential steps linked by the development of data files. This was a complex and dynamic process involving much trial and error.

R also developed computer-assisted learning (CAL) programs for tutorial purposes in laboratory courses.

The computing requirements of R's major application forced him to do this work in batch mode, usually using queue 10. R described the one-per-day turnaround for queue 10 jobs as a little slow; for jobs in the other queues, R had used the higher priority option to effect. R also had some plotting requirements; for test plots he used the Statos in the Engineering terminal and, for final copies, the Calcomp at the

Centre.

R would like to work in a totally interactive computing environment. The present resource limits for CANDE tasks prohibit program compilation. His use of CANDE for his major application is limited to some program development and placing jobs in the batch queues from the terminal. R reported a serious problem of terminal availability for CAL purposes. Also, he was frustrated with CANDE access hours. His scores on the ACCESS and TOOLS factors suggest that his satisfaction in these areas was about the average for all CANDE users.

R's expenditure was approximately $350 per month. Obtaining funds was no problem; availability of funds, he said, depended on his head of department. However, he was affected by the costs for memory integral (levied per kilo-word/second) which varied with the core type; if his programs were run in certain modules of fast core, costs were less.

His score on the HELP factor reflects his overall positive feelings towards the informational support services. With new or unfamiliar things, he looks to the documentation. He took some deficiencies in it to the documentation editor, who was responsive. He has taken various problems to the Duty Programmer, and usually received adequate help.

R's low score on the USERS' GROUP factor was in accordance with our interview findings. For him, the Users' Group was a big area of concern, and he spoke at length on its deficiencies. As a means of communication, he found it too formal, and he believed that there were more effective means, e.g. the suggestions book. He had a feeling that at meetings, the Computer Centre was prepared to talk about what they were doing, but not to find out what users would like. He had raised the matter of access hours at meetings, but gained no concession. He considered that access hours were a policy matter for the Computer Centre to decide, rather than its supervisory Computing Facilities Committee (see Appendix C for details of the administrative structure). He found the low

attendance at meetings disappointing, and believed that there was a bias towards research users.

He also believed that the Users' Group should have an educative role, such as for presenting the views on computing of users returning from study leave.

Despite R's frustrations with the Users' Group, he reported no problems in his interaction with staff, which ties in with his high score on the PEOPLE factor.

4.3.2 Case Study II

This interviewee, known as K, was selected from the batch users in the 1980 sample. His factor scores are listed below.

FACTOR	SCORE	QUARTILE
PEOPLE	+0.37	2
ACCESS	-2.14	1
BATCH	-0.65	1
HELP	-0.69	3
LOCATION	+0.33	2

K was a second-year Computer Science student. His Computer Science, Mathematics and Accountancy courses had required programming assignments in FORTRAN, PASCAL, COBOL and 360 assembler. K had used the Computer Centre's Burroughs and undergraduate systems, and also his department's mini-computer. Programming assignments were very time-consuming, he said, and he was having a very busy year.

For all students in his class, access to the Burroughs system was restricted to the submission of queue 1 batch jobs via a courier service which was run by his department. He found the "think-time" allowed between the delivery of his output and the collection of input too

short. Although the courier service ran every 2 hours, he thought that the service was badly timed, and that boxes of card decks weren't immediately entered by the operators. If you stuck to the rules, he said, at most 2 or 3 runs per day were possible and this was quite frustrating. Accordingly, his score on the BATCH factor was low, and his score on ACCESS was extremely low.

Sometimes he worked outside the rules to get better turnaround. At times, he had used the Engineering batch terminal, pretended to be a courier, or taken individual jobs directly to the Centre. Sometimes these strategies had been successful, but sometimes the operators had objected.

Regarding information support, the combination of help from manuals, lecture handouts, lecturers and friends seemed quite adequate. K had seen a duty programmer (despite official rules to the contrary) about a few WFL and COBOL syntax problems, and he found them very helpful.

In bending the rules to circumvent the courier service, he came into conflict with the operators at times, but he didn't get a consistent response from them in those situations. Some accepted his extra runs, and some rejected them. Some operators were polite, and some gave him the impression that they were sick of the sight of him - "You can pick em'", he said. This might explain why his score on the PEOPLE factor was below average.

He found that the funds allocated for his assignments restricted his activities. Usually, the amounts were adequate if he worked economically. Sometimes, funds were insufficient, and there would be an extra allocation. In this way, money was "a guideline for resource use"; however, the attitude imposed was that the aim of the restrictions was to conserve both money and resources.

4.3.3 Case Study III

This subject, W, was selected on the basis of his scores on the 1980 CANDE factors, which were as follows:

FACTOR	SCORE	QUARTILE
PEOPLE	+0.18	2
ACCESS	-1.33	1
PROBLEMS	+1.77	4
HELP	-0.56	1
TOOLS	-0.03	2
USERS' GROUP	-0.53	1

W was a postgraduate student in the Economics Department. He had gained considerable computing experience while working as a systems programmer in a bureau some years previously, and regarded himself as a competent user. More recently, W had been employed as a research assistant, developing large interactive modelling programs. Currently, he was taking an M.Sc. paper which required him to use TEMPO and MODELLER, two Burroughs mathematical programming languages.

This course work was done using the batch service provided at the Centre. He found that this service was very good for work that didn't have to be run interactively, and that the Centre was conveniently close to his department.

W had used CANDE during his employment as a research assistant. There were conveniently located terminals, and he had no problem getting onto the machine. Although he liked the facility, the implementation was slow and restrictive. He understood the predicament of the overloaded resource, but the slow response was frustrating and the task resource limits were a big problem. The limit on processor time prevented interactive use of certain large programs. He said that he would use a

terminal facility at night if he could run large jobs interactively with less restriction. Another problem was the availability of on-line storage. He found his allocation of 3,000 segments restrictive. (A segment is equal to 180 bytes.) His comments about CANDE tied in well with his low score on the TOOLS factor and particularly low score on the ACCESS factor.

W usually relied on his colleagues for help. For some problems he used the duty programmers and found them "excellent"; this corresponded with his high score on the PROBLEMS factor.

He considered the structure of the Burroughs TEMPO and MODELLER package manuals "bad to reasonable". However, he was satisfied that they contained the necessary information, He thought that the manuals for WFL, CANDE and the I/O subsystem were good, but those for the utilities, particularly for graphics, were poor.

He received all Computer Centre documentation. He made extensive use of the Users' Guide, even though he considered it "very badly organized". He saw a lack in the area of overview documentation, which he conceded was possibly covered by the User Notes series. His low score on the HELP factor was related to his obvious dissatisfaction with certain aspects of the documentation.

W had some criticisms of the operators. They referred problems, such as with tape formats, which he considered "they should know about", to the duty programmer. Also, he found them intolerant of his unauthorised use of disk space; once he had all his files archives during a system crash, because he was using more than his allocated area. These experiences seemed to have contributed to his feelings of dissatisfaction summarised by his low score on the PEOPLE factor.

W made much use of the data preparation service. He was annoyed at the ruling that program sources decks would not be verified (as data decks can be). In one instance, he had 4,000 cards punched from

FORTRAN source listings, and he felt that these should have been verified. He found that the keypunch operators were fussy about coding and would "spot ambiguities which aren't ambiguous".

W said that he was careful, in his own way, about the use of funds, and had never found money to be a problem or restriction. He considered his own effectiveness more important than saving funds.

In contrast with his own experiences, most users, he thought, were unaware of the cost of their work. For this reasons, he thought the role of the duty programmer and the Users' Group should be more educative.

4.3.4 Case Study IV

The interviewee in our fourth case study, S, was selected on the basis of her scores on the 1980 batch factors:

FACTOR	SCORE	QUARTILE
PEOPLE	+0.87	3
ACCESS	+1.63	4
BATCH	0.00	2
HELP	-0.73	1
LOCATION	+1.73	4

S was a lecturer at Lincoln College who had used a variety of statistical packages on several systems. She was currently learning to use GENSTAT on Lincoln College's VAX system, as she was about to teach it for part of a Masters course involving experimental design.

S's access to the Burroughs had always been via the Lincoln batch terminal. She had been very impressed with the turnaround here, particularly in comparison to that at Massey. Her comments matched her high score on the ACCESS factor.

She had not learned to use the CANDE system because she hadn't

needed to use it; she "knows how cards work" and has some reservations about using magnetic media. She said that she wouldn't change unless she had to, and she anticipated a large effort in doing so.

S had experienced no problems obtaining funds; she didn't understand Lincoln College's "funny money" scheme, but it caused her no difficulty.

S observed much variation in the quality of reference manuals. The SPSS manual was "excellent", but she didn't use this package any more. Other package manuals were confusing, had poor examples, were loaded with jargon and lacked statistical explanations. She though that they were written for people who know what they're talking about. S spoke of a big culture barrier, and expressed the opinion that "computing makes you feel ignorant", although she said that she didn't worry about this. Her score on the HELP factor was accordingly low.

Being at Lincoln, S had no direct dealings with staff of the University Computer Centre. She found the staff of the Lincoln College Computer Centre very helpful, although there were no specialists in her field. She had worked on a fairly low level of sophistication with WFL; changes to her standard card deck were not easy to make, so she simply asked someone.

4.3.5 Summary of Interview Findings

The purpose of the behavioural model used in this research was to describe the influences on the user's evaluation of the services. This evaluation comprised the user's strategy for using the services and his/her satisfaction with them. According to the model, this evaluation is influenced by a wide range of user needs and the provisions made by the services for meeting those needs. The interviews confirmed that this was a realistic model of the situation, and it provided a useful framework for carrying out the investigation and viewing the results.

The interviews showed that most users' needs were being met by the services provided for them. At the same time, nearly every user had experienced restriction, difficulty or frustration with at least one or two aspects of the service.

It was usually possible to see how this dissatisfaction arose. In some cases, it was because of one or two bad experiences; in others, it was because long-standing needs were not being met. In a few cases, we felt that certain of a user's perceived needs were such that they could not be met by any computing service. Clearly, the evaluation of services by all users was influenced by those aspects known as "personality". Because of our lack of formal training in this area, we did not attempt to evaluate this influence. Rather, we acknowledged its existence and restricted our attention to more tangible aspects of the user-service interaction.

Two factors emerged from the interviews as being very important in determining a user's computing needs: the kind of work undertaken and the degree of the user's involvement in computing. The kind of work undertaken, or the user's application(s), influenced the range of facilities employed (particularly special hardware, such as graphics equipment), the user's software mode, and to some extent the user's choice of medium. The degree of the user's involvement in computing was most strongly associated with usage of the system, but also with computing skills and familiarity with the system, personnel and support mechanisms. The user's involvement most directly indicated his/her operational requirements of the system, but also needs of the support services.

The results of the factor analyses (presented in Section 4.2) had shown that these characteristics which we now associated with the user's involvement were positively related to the user's satisfaction with the user-staff interaction factors (e.g. PEOPLE) and negatively related to

satisfaction with various operational factors (BATCH, CANDE, ACCESS, etc.). The interviews showed that the more involved users were more likely to be in frequent contact with staff and this personal contact established an effective working relationship. At the same time, the operational aspects of the service were least satisfactory for the more involved users because they made greater demands of it, and encountered its restrictions more often.

These findings account for many of the associations reported previously between the factor scores and user and use characteristics. In this way, the interviews provided practical explanations for our data analysis results, and further insight into the nature of user-service interaction. Our observations regarding more specific aspects of the interaction for which there was substantial comment are summarised below.

(a) Batch service. Users' feelings about the batch service depended on their needs, their expectations of turnaround, and their strategy for using it. Some users adopted a strategy of entering jobs and returning when they expected them to be ready. Others, such as those doing development work which needed fast turnaround, waited for their jobs to be completed. Some of these users were frustrated by the operator delay in handling input and output. Users of the Engineering batch terminal found this access valuable.

Several users were frustrated with the lack of predictability of turnaround time. Some wanted to get more runs in queues 2 or 6 through per day. The turnaround of one run per day in queue 10 was unsatisfactory for one user. Some users with needs for fast turnaround, and the necessary funds, used the high priority option available in queues 2 and 6. The differential charging scheme appeared to be quite satisfactory for them, and we had no adverse comments from other users, either. Naturally, users without the need for fast turnaround were

quite satisfied.

The location of batch services had some influence on satisfaction. Users located near the Centre or Engineering terminal were satisfied, as were those with low turnaround requirements who passed by on their way to and from work.

(b) CANDE service. Users of the interactive service were more aware of, and were less satisfied with, technical aspects of the service than batch-only users. Some disliked the editor, however the major criticisms concerned the implementation of CANDE: the slow response times, the restricted access (both in terms of hours and number of terminals) and the task resource limits.

There appeared to be some competition between users for terminal access. Given the scarcity of this resource, the booking facility seemed invaluable. A few users who booked in advance reported no problems with access. One or two admitted using "dirty tricks" to obtain more than the limit of one terminal hour booked in advance. The introduction of the morning CANDE session was appreciated. The Social Science terminal cluster seemed particularly attractive to several users because of its slave printer with upper and lower case characters.

A few users with large interactive programs complained that the resource limits were inadequate. This appeared to be the major problem for CANDE users with large modelling applications. A more commonly expressed frustration was with response times. Some users were aware of great variability in response, and observed that when the system was very busy, it was extremely slow.

Despite considerable growth in the use of CANDE, several factors appeared to inhibit its use. Several users reported that it was hard to start learning and to become familiar with the system. One user had difficulty understanding the error messages and handling the terminal. Another was "overwhelmed by the high technology", and

terrified about the interaction. For another, the use of batch was familiar, cards were tangible, and the effort of learning was not worthwhile for the small requirements of the application.

Some other users were reticent for technical reasons, such as the lack of on-line storage. Users whose applications required graphical output appeared to be dissatisfied with the current graphics facilities. The provision of convenient, high-quality graphics terminals compatible with present software would be of great benefit to them, and would take the load off the present plotters. Two staff members hoped to see big improvements in the teaching facilities available, such as a cluster of terminals for CAL purposes. At least another two gave the sorts of reasons already stated for having their students use only departmental computing equipment.

(c) Support services. Documentation was identified by the 1978 survey as a critical area of the service provided at Canterbury. Accordingly, we noted significant comments about informational support in general from roughly half of the users interviewed.

Most criticism concerned the Burroughs language manuals (including those for WFL and CANDE) or the Computer Centre's Users' Guide. Users generally agreed that these documents contained the necessary material, but found them hard to use. Several commented that they were difficult to use at first, and we noticed that most users who were happy with them were experienced users.

The greatest deficiency was for introductory documentation. However, it appeared that this was being met in certain areas by the User Note series. Two comments that we recorded were: "very definitely an improvement" and "an impressive improvement; just the right level". Positive feedback was recorded concerning the User Notes on CANDE and application packages. Users expressed their needs for similar documentation describing the whole range of services available, on WFL,

on file and tape handling, and on program libraries and binding.

A variety of comments were received regarding the software support provided by Centre programmer/analyst staff. Some users in the first group we interviewed were unhappy about the availability of staff, and some found making simple enquiries difficult. Generally, staff gave a friendly impression but some appeared bothered by trivial questions. One user complained about a lack of support for packages and a lack of expertise in numerical specialities. Another user was frustrated by finding no one who would take responsibility for PL/1. Yet another found that the duty programmers were not familiar with the documentation; he thought that the documentation should back up their advice, and that their role should be more educative.

Other users praised the service for being very helpful and accommodating. Some of these users personally knew staff and enjoyed easy communication with them. One user with an effective relationship with operators and programmers said that the key to success was that they told him how to do things in words he could understand.

Only a few users commented on courses run by the Centre. Two of them detected a wide range of ability among attenders; one emphasized the need for introductory courses, "particularly to pick up the skills of enquiry". Another user wanted demonstrations of the use of card punches and the enquiry system.

Users waiting at the Centre for their input and output to be handled by the operators experienced some frustration. For this reason, one user changed to using the Engineering batch terminal for better access. Another recognized a certain tension arising from both users and staff, and found that tact was necessary in these situations. Several users had difficulty using the Calcomp plotter and communicating their requirements to the operators. On the other hand, many users found the operators very helpful.

One user was very pleased about them having a tape conversion job done for him. Another got special assistance when he had urgent work to do. Overall, the operational support provided to users seemed to depend on the other commitments of operators, but the quality of this service was adequate.

Few users had comments to make about technical aspects of the service. It seems that users experienced few problems at this level of interaction and that technical support was usually taken for granted. Three users complained about the reliability of the card reader in the Engineering batch terminal. One thought that the paper tape reader at the Centre read too fast, and thus caused "an awful lot of errors". A user who found the output of the Statos plotter too murky instead used the Calcomp; this proved to be a bottleneck which restricted his work. One user expressed his thanks for a difficult data transfer job undertaken by a technician.

User comments about the Centre's data preparation service were very favourable. Most users who detected punching errors traced these to their own coding errors. Overall, it was obvious that this was an adequate and satisfactory service.

(d) Allocation and administration. Few users, apart from the undergraduates we interviewed, were seriously restricted by the availability of funds. On the other hand, most users were aware of their spending and made some effort to work economically. Two users with high expenditure were concerned about the charging algorithm and the charging and funding procedures.

The general restriction on the computing resource seemed to produce different responses from different users. Some were conscious of the shortcomings of the system and saw that this caused irritation to all users. A few committed batch users felt that batch was unfairly penalised while CANDE was run, and some CANDE users felt that the system

was slanted against them. Some users complained that students "soaked up terminal bookings" and that their jobs slowed the system.

Several users spoke of their dissatisfaction with the Users' Group; they had sensed some antagonism at meetings and disliked it. The attraction for some was to gain information on purely technical matters, such as the imminent arrival of new equipment. For those seeking two-way communication with the Centre, the Users' Group appeared an unsatisfactory medium. Two users said that they preferred to approach staff informally. One said he got excellent response using the suggestion book.

Despite the apparent deficencies of the Users' Group, the relationship between users and the Centre was good. To a large extent, this was because of personal knowledge and contact and a generally positive, helpful response from staff.

(e) Miscellaneous findings. For some users, experience with other computer systems and services provided extra basis for their evaluation of the Burroughs system and support services. Some found CANDE slow and difficult to use, and access poor, in comparison with other interactive systems. Two users said that for these reasons they preferred to use their department's mini-computers; they used the Burroughs only because of the software available on it, and its capability for handling masses of data. Another said that in comparison to the service he experienced overseas the local turnaround was better, the system was easier to use and the Centre was better run and friendlier. Nevertheless, it appears important that the Centre continue to provide a wide range of services, including a powerful and convenient interactive system, in order to retain its users.

Another finding concerned the sources of help available to users. Several users worked closely in conjunction with others, or regularly got help from peers. Students, in particular, tended to tackle problems themselves. Undergraduates were not allowed to seek help from the duty

programmer, although some did so. The support and encouragement of other users within the same department was quite important to some, especially those starting out. There appeared to be considerable expertise among staff members in Science and Engineering departments. We saw this expertise as both a cause and an effect of high use by these departments.

Several users reported difficulties when using the system after a period of disuse. One said that this was a problem of his sporadic use that was compounded by changes in the system. The needs of users with this relearning problem appeared quite similar to those of beginning users.

4.4 SUMMARY OF RESULTS

In this section, we summarize the results of our two investigations at Canterbury and present our conclusions regarding the effectiveness of the services provided and the influences on user behaviour and satisfaction.

Our first conclusions concern the undergraduate students, who formed a distinct group within the user population. Their computing needs were not extraordinary - they required fast turnaround for the development of small programs - but their satisfaction differed from that of other users because of the conditions imposed upon their use of the services. The undergraduates were less satisfied with their funding and with several of the user-staff interaction and operations factors. Access to a batch terminal or interactive terminals would provide some relief. However, this would not avoid their departments' needs to restrict resource usage and encourage efficient work patterns.

For the other users - the staff, postgraduates and external users - differences in background, skills and the forms of interaction employed were more important than differences between status categories.

The importance of skills and experience in computing is intuitively obvious: certain levels of skill with various tools are essential to productivity. The survey data showed that skill was positively related to usage; the interviews showed that computing skills were generally acquired through use of the system. Just as most users used the system only as much as necessary, most learnt only as much as required to complete their immediate task. We believe that this is related to the role of the computer for the amateur programmer: it is a powerful and essential tool for solving particular problems, yet its use is only a small part of the amateur programmer's work.

The assistance of other users was quite important to the learning user; they could provide the practical expertise and encouragement

necessary to get started. Most students received considerable instruction in computing, but not necessarily practical directions for using the system, in University courses. Computer Centre service courses were appreciated by the few users who had attended them.

The user's mode of interaction was determined to some extent by the kind of work undertaken. Packages were used predominantly for data analysis, but also for information processing and in certain mathematical problem-solving situations. Package and programming users were more skilled, used the system more, and were more likely to use CANDE.

Batch has been the traditional medium at Canterbury. However the proportion of users employing CANDE increased from approximately 25% in 1978 to 52% in 1980. This growth has occurred despite restrictions on the availability of CANDE, and the frustration this has caused users.

Nearly all users still used batch services to some extent in 1980. Those who also used CANDE were generally more involved than those using only batch: they were more highly skilled and used the services more. CANDE use was also associated with high expenditure; both of these were prevalent in those departments with the greatest historical background in computing. We believe that this background has enabled some (notably Science) departments to accrue the large grants and local expertise necessary to support and encourage computer use on a large scale.

CANDE use was also more prevalent among programming users than among package users. In part, this is related to the effects described above: the kinds of work undertaken by users in departments new to computing was more suited to package use. Also, their lesser degree of involvement and the unsuitability of much of the current package software for interactive use made the change to the interactive medium less attractive to package users.

The processing capability provided to users was the greatest area of dissatisfaction. The overall inadequacy of the computing resource was indicated by the low effectiveness ratings for operational factors. This was confirmed by the predominance of operational topics among critical service aspects (see Section 4.1.8) and the comments of users during interviews. Most batch users were frustrated only by the slow turnaround during busy periods, but the growth in CANDE usage placed great demands on the system and this service was often unsatisfactory.

It appears that the range of facilities provided at Canterbury met nearly all needs. However, there were growing demands for improved graphics facilities and more interactive terminals. The most desired arrangement for interactive access was a cluster of VDU's with an upper and lower case printer, bench space and documentation, within user departments.

While all users relied on the computer system for its processing capability, the interaction with Centre staff that this use required was a major component of their satisfaction. The importance of the support services emerged from the construction of the effectiveness measures and was confirmed in interviews with users. We found that users required help usually when in a situation of some difficulty or frustration, and the availability of helpful and competent staff in these situations was essential. Overall, the personal support provided by Centre staff was adequate, as shown by the high effectiveness ratings of the PEOPLE factors. However, CANDE users appear to be placing greater demands on operations staff. The operators' workload could be reduced by the provision of a batch terminal at the Centre. At the same time, this greater access would provide a better service to users and avoid the frustration inherent in the present arrangement.

One of the major findings of our investigations was the importance of the user's degree of involvement in computing to his/her satisfaction

with the service. The more highly involved users were generally more satisfied with their interaction with the staff, but were less satisfied with the computer system itself.

Although the operational requirements of heavily involved users were greater, their needs in the area of informational support differed in both quantity and quality from those of other users. They appeared quite comfortable with technical reference manuals, and capable of learning new things for themselves and coping with technical detail. By contrast, beginning users or those users learning new skills required much introductory information and general guidance. We found that the User Note series reached 40% of the 1980 sample, and we received much favourable feedback about its introductory style. Despite this, several users who were interviewed had not heard of the User Notes, and we concluded that they needed more promotion to bridge the obvious communication gap.

We found that the Centre had many long-standing users who worked on a fairly low level of sophistication, using tried and true programs, usually by batch. These users tended to make do with what they knew, primarily because the requirements of their work changed little. Some of these users experienced difficulty when they used the system, because of the long periods of disuse, and system changes. It remains a challenge for staff to provide adequate support for new and relearning users.

Users appreciated the help of the duty programmer service, and users who personally knew staff reported no problems. However, there is a need for more sensitivity to individual requirements: less skilled users need careful explanations, not necessarily instant solutions. There is also a need for greater integration of the two informational support mechanisms; staff should be familiar with the (improved) documentation and be able to direct users to an appropriate document. We believe that these two measures will increase the educational role of

the duty programmer and help users to solve their own problems.

Users' Group attendance was found to be considerably biased towards the more involved users. The satisfaction responses of attenders indicated a certain ambivalence: compared with non-attenders they were generally more happy with the staff, but less satisfied with the operational service provided. The topics of concern to attenders changed between 1978 and 1980, most noticeably from the batch service to the interactive service. Satisfaction with the Users' Group itself increased significantly over this period. Despite some criticisms of the Users' Group, it appears to be a valuable medium of communication. At the same time it is important to recognize that neither the attenders nor their concerns are representative.

CHAPTER FIVE

CONCLUSIONS

The purpose of this research was to develop a management tool for investigating and measuring the effectiveness of a computing service centre. Development of the tool required two investigations of the services provided at the University of Canterbury. Results of this work have been used in policy formation by the Computer Centre and incorporated in its long term plan (Good and Brown, 1981).

We conclude that worthwhile information for a concerned computer centre management can be obtained relatively easily using this tool. Its use enables management to assess the centre's effectiveness, it directs attention to unsatisfactory aspects of the service and it provides input for decisions on the deployment of resources. The tool measures effectiveness in terms of user satisfaction; repeated use of the tool will expose changes in satisfaction and use over time. The method allows management to find out at a practical, detailed level what makes the individual user satisfied. As now developed, the tool is economical: we estimate some 4 to 6 person-weeks' work spread over 3 or 4 months and some use of a computer with a statistical package.

We believe that this management tool could provide useful input for other forms of review of a centre's effectiveness, such as peer review.

Since its development and use at Canterbury, the tool has been used at the University of Otago (Burnside, 1981). The two centres provide similar services with similar equipment to amateur programmers. It is intended that the tool will be used at other centres which provide different services to amateur programmers. Future research may be directed toward the services provided in other computing environments to professional programmers and naive users. In this way, it will be

possible to observe consistent patterns in the user-service interaction of certain categories of users and to verify the user satisfaction factors discovered in this research.

ACKNOWLEDGEMENTS

I would like to thank John Good for his enthusiasm and supervision of this project, Prof. John Penny for authorising this hitherto unusual Computer Science research, Ms Gill Coe for her support, the least of which was typing the draft and final copies of this thesis, and my parents for giving me the capability, confidence and finance to do this work.

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APPENDIX A

QUESTIONNAIRE USED IN 1978
INCLUDING SUMMARY OF RESPONSES

NOTES:

1. Where possible the responses to each question have been summarised. The figures show the percentage of valid responses received for each category, or other summary statistics for the valid responses.

2. Question 3 is the major type of work done on the computer. As there could be some overlap of categories, up to two alternatives were allowed.

3. Various comments were received to the open-ended questions 32 and 33; common replies are listed there.

Department of Computer Science
University of Canterbury Christchurch 1 New Zealand

ASSESSMENT OF THE EFFECTIVENESS OF
UNIVERSITY COMPUTING SERVICES

The attached questionnaire is part of an honours research project to develop a tool for measuring effectiveness of university computing services. It is being undertaken by an honours student in the Computer Science department, under the supervision of Mr John Good of the Computer Centre.

You have been chosen at random as one of a number of computer users to participate in the pilot study. Our primary objective is to assess the suitability of using the questionnaire technique as a tool for measuring effectiveness of university computing services. Therefore, we would be very interested in any comments regarding the technique used. As a secondary objective, we are interested in the relationship between user characteristics and corresponding satisfaction levels or user assessment of the computing services. All information will be treated as strictly confidential.

Your co-operation in completing the questionnaire will be greatly appreciated. If you have any problems or require further clarification, please do not hesitate to contact either Mr Good (Computer Centre, ext. 85) or myself (main exchange ext. 734). Please return the questionnaire to me at the above address by 22nd September 1978.

Mary Chen
4 September 1978

USER PERSONAL EXPERIENCE (SVC) 1 | 5 | 0 | 2 | | | | 6

(1) Which one of the following best describes your status as a user?

1. Academic staff member (33%)
2. Postgraduate student (23%)
3. Undergraduate student (26%)
4. External user (13%)
5. Other (please specify) ..... (5%)

7 [ ]

(2) Which one of the following best describes your major purpose for using the computer?

1. Because it would be impossible to undertake the work otherwise (33%)
2. The work would otherwise be limited in scope (14%)
3. To save time and effort (19%)
4. The computer itself is an inherent part of the study (33%)

8 [ ]

(3) Which one of the following best classifies the major type of work you do on the computer. If you cannot decide among alternatives, enter two.

(3.1 and 3.2)

1. Number crunching, i.e. large amount of CPU time
2. Package analysis, i.e. extensive use of statistical and other packages
3. Data processing, i.e. large amount of I/O and information retrieval
4. Developing computer models
5. Teaching, e.g. CAL
6. Learning programming

9 [ ][ ] 10

(4) How long a period of instruction in computing have you received?

1.	None	(12%)
2.	Less than one week	(13%)
3.	One week - one month	(16%)
4.	One month - six months	(18%)
5.	Over six months	(41%)

11 ☐

(5) Where did you receive your instruction (if any) in computing?

1.	Not applicable	(9%)
2.	Machine company training course	(2%)
3.	Computer Centre service course	(8%)
4.	Self-taught instruction course	(16%)
5.	University unit	(51%)
6.	Other (please specify)	(15%)

12 ☐

(6) What is your average gross expenditure on computing per month?

1.	Less than $5	(28%)
2.	$5 - $20	(34%)
3.	$20 - $50	(13%)
4.	$50 - $100	(8%)
5.	Over $100	(10%)
6.	Don't know	(7%)

13 ☐

If your use of the computer involves writing programs (as opposed
* to providing data for packages), answer questions (7) and (8).
Otherwise please leave blank.

* (7) How do you write your programs?

1. In collaboration with others (apart from consultants, etc.) (10%)
2. By yourself (70%) [14]

* (8) Once your typical program is developed, will it:

1. Be used repeatedly with different parameters and/or data? (35%)
2. Have provided the end solution to the problem and will not be run again? (32%) [15]
3. Be run again after modification or incorporation with other programs? (13%)

(9) Please indicate the extent of your knowledge in the following languages, and the percentage of your work done in them.

	KNOWLEDGE					WORK	
	No Knowledge	Workable			Capable & fluent	% work done in this language	No work done
9.1 FORTRAN	1 10%	2 11%	3 24%	4 27%	5 28%	[16]...[18]	23% [19]
9.2 ALGOL	1 48%	2 12%	3 13%	4 15%	5 12%	[20]...[22]	60% [23]
9.3 COBOL	1 78%	2 5%	3 7%	4 7%	5 2%	[24]...[26]	86% [27]
9.4 PL/1	1 93%	2 5%	3 2%	4 0%	5 1%	[28]...[30]	99% [31]
9.5 Assembler lang. (any type)	1 66%	2 7%	3 15%	4 4%	5 9%	[32]...[34]	82% [35]
9.6 Statistical & other packages	1 60%	2 9%	3 16%	4 11%	5 4%	[36]...[38]	67% [39]
9.7 Other lang. (if applicable)	1 82%	2 2%	3 5%	4 5%	5 6%	[40]...[42]	91% [43]

.....

(10) Which of the languages in Question 9 did you learn first (indicate one from 1 - 7)? [44]

USE OF SUPPORT FACILITIES

(11) How do you principally use the computer?

1. By feeding parameters/data into given packages (30%)
2. By writing small procedures or sections to be added to a supplied program (5%)
3. By writing entire source programs to solve a problem (54%)
4. By writing batches of programs to solve a major problem (11%)

45 ☐

(12) Through which medium do you usually communicate with the computer?

1. Local batch at Computer Centre (62%)
2. Remote through CANDE terminals (6%)
3. Remote batch at Lincoln College, Engineering batch terminals (30%)
4. Give your requirements to someone else, who interprets them and gives back the desired results (2%)

46 ☐

(13) How would you summarise the distribution of your computing activity over a year?

Very Irregular		Sporadic		Regular
1 (13%)	2 (8%)	3 (36%)	4 (27%)	5 (16%)

47 ☐

(14) Roughly speaking, how often do you consult a Duty Programmer?

Never	Yearly	Monthly	Weekly	Daily or more often
1 (18%)	2 (35%)	3 (37%)	4 (10%)	5 (0%)

48 ☐

(15) How often do you consult reference manuals?

Never		Occasionally		All the time
1 (4%)	2 (12%)	3 (42%)	4 (30%)	5 (11%)

49 ☐

(16) Do you have a copy of the User's Guide?

Yes	No
1 (54%)	5 (46%)

50 ☐

(17) Do you receive regular copies of the Newsletter?

1	5
(49%)	(51%)

51 ☐

(18) How many User's Group meetings do you attend per year?

52 ☐

0	1	2	3	4 or more
(76%)	(9%)	(4%)	(7%)	(4%)

(19) How do you usually prepare the majority of input for your programs and data?

1. Use professional data preparation facilities at the Computer Centre or Lincoln College (51%)
2. Do own keypunching (44%)
3. Explain your needs to someone else (4%)

53 ☐

(20) How do you normally receive output for your problems?

1. Pick it up from the Computer Centre or batch terminal yourself (81%)
2. Have it brought to the department by courier (17%)
3. Receive a report prepared by someone else from computer output (1%)

54 ☐

USER SATISFACTION

If you have particular comments about any questions in this section, please add them to those in Question 32.

	Highly dissatisfied		Neither satisfied nor dissatisfied		Highly satisfied	
(21) Are you a batch user? If so, how satisfied are you with:						
21.1 Turnaround time	1 (5%)	2 (28%)	3 (26%)	4 (31%)	5 (10%)	55
21.2 Hours of availability of batch facilities	1 (5%)	2 (22%)	3 (25%)	4 (29%)	5 (20%)	56
21.3 Present queue and priority structure	1 (2%)	2 (7%)	3 (36%)	4 (38%)	5 (17%)	57
21.4 Extent to which you are advised of unscheduled delays (due to breakdowns, etc.)	1 (5%)	2 (16%)	3 (45%)	4 (20%)	5 (14%)	58
21.5 Location of batch facilities (RJE or Centre)	1 (2%)	2 (10%)	3 (35%)	4 (27%)	5 (27%)	59
(22) Are you a CANDE user? If so, how satisfied are you with:						
22.1 Response time for editing	1 (0%)	2 (18%)	3 (23%)	4 (50%)	5 (10%)	60
22.2 Response time for execution of tasks	1 (7%)	2 (21%)	3 (43%)	4 (19%)	5 (10%)	61
22.3 Hours of availability of CANDE	1 (22%)	2 (37%)	3 (15%)	4 (20%)	5 (7%)	62
22.4 Range of facilities available	1 (7%)	2 (17%)	3 (20%)	4 (37%)	5 (20%)	63
22.5 Ease of obtaining assistance in case of breakdown during a CANDE session	1 (8%)	2 (13%)	3 (49%)	4 (23%)	5 (8%)	64

	Highly dissatisfied			Neither satisfied nor dissatisfied		Highly satisfied	
How satisfied are you with:							
(23) Response of Computer Centre to problems that you experience (e.g. software bugs, hardware breakdowns, supply shortages, etc.)	1 (4%)	2 (8%)	3 (42%)	4 (28%)	5 (18%)		65
(24) Adequacy of the Duty Programmer service	1 (4%)	2 (13%)	3 (41%)	4 (30%)	5 (12%)		66
(25) Availability of Computer Centre staff	1 (1%)	2 (10%)	3 (40%)	4 (32%)	5 (18%)		67
(26) Quality and administration of data preparation facilities	1 (1%)	2 (10%)	3 (35%)	4 (25%)	5 (29%)		68
(27) Quality of available documentation	1 (12%)	2 (19%)	3 (33%)	4 (28%)	5 (9%)		69
(28) Willingness of Computer Centre to make provision for an unusual requirement	1 (2%)	2 (4%)	3 (53%)	4 (25%)	5 (17%)		70
(29) The User's Group as a medium of communicating your needs	1 (2%)	2 (7%)	3 (83%)	4 (5%)	5 (3%)		71
(30) Adequacy of computing funds to support your projects	1 (2%)	2 (9%)	3 (23%)	4 (33%)	5 (35%)		72
(31) Fairness of the charging algorithm	1 (4%)	2 (11%)	3 (44%)	4 (28%)	5 (14%)		73

(32) GENERAL ASSESSMENT

If you have any additional suggestions or criticisms regarding the provision of computing services at present, we would be glad to receive them. It would be helpful if you could list the characteristics of the Burroughs system and its satellites under the following headings:-

Helpful/Good/Supportive Frustrating/Unsatisfactory

Various comments were received. The main points are listed below:

- too complicated WFL commands
- introductory courses for CANDE and WFL would be helpful
- low quality of documentation in general
- not enough primers for new users

(33) GENERAL COMMENT

Any other general comments. In particular, if you have any comments regarding this questionnaire (format, depth, content, etc.), we will be pleased to receive them.

The main faults found with the questionnaire are listed below:

- possible answers for questions 2,8,9,11,12 were not mutually exclusive
- question 4 should specify a time period
- question 5 should perhaps include "overseas" as an alternative
- more specific questions are required on particular aspects of the service, e.g. plotter quality, use of graphics equipment

THERE ARE 9 PAGES TO THIS QUESTIONNAIRE. PLEASE CHECK THAT YOU HAVE FILLED OUT ALL THE PAGES. THANK YOU FOR YOUR CO-OPERATION.

APPENDIX B

QUESTIONNAIRE USED IN 1980, INCLUDING SUMMARY OF RESPONSES AND FOLLOW-UP LETTER

NOTES:

1. Where possible, the responses to each question have been summarised. The figures show the percentage of valid responses received for each category, or other summary statistics for the valid responses.

2. Various comments were received to the open-ended questions 36 and 37; common replies are listed there.

Department of Computer Science
University of Canterbury Christchurch 1 New Zealand

ASSESSMENT OF THE EFFECTIVENESS OF
UNIVERSITY COMPUTING SERVICES

The attached questionnaire forms part of a survey that is being used in a study of the effectiveness of university computing services. The work is being undertaken by the undersigned as a joint Computer Centre/Computer Science Department project.

You have been chosen at random from the population of users of the Burroughs system, and you are asked to supply certain information concerning the computing that you do. We want to study various characteristics of the computer services and the users and see how these relate to user satisfaction. We hope to test a number of hypotheses that originated in the course of a pilot study which was started by Mary Chen and John Good in 1978.

We wish to obtain a fair picture of the user population, so please respond whether or not you regard your use of the computer as important and whether or not you have strong views about it. Instructions for completion of the questionnaire are given overleaf. All information will be treated as strictly confidential.

If you require further clarification, please do not hesitate to contact either of us: John Good (phone 488-237 (Computer Centre), ext. 85), or Chris Power (phone 482-009 (University), ext. 719). Please return the questionnaire to the above address by 22nd July 1980. Your co-operation will be greatly appreciated.

1 July 1980

John Good
Chris Power

INSTRUCTIONS FOR COMPLETING THE QUESTIONNAIRE

1. Please complete all questions considering your own use of the facilities provided by the Computer Centre at Ilam.

2. Where you are asked to select one of a range of alternative answers, please enter in the box on the right the number which corresponds to your choice.

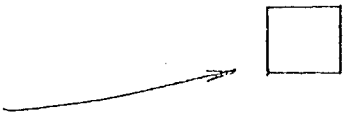
   Example A:

   1. answer one
   2. answer two
   3. answer three
   4. answer four

   If you select answer three enter a '3' here 

   Example B:

Yes	No
1.	5.

   If your answer is 'No' enter '5' here 

3. Where you are required to supply a numeric value, please enter your value in the spaces provided. For example:

	7	0	%

4. If a question refers to a service that you do not use, or is in some other way irrelevant, please leave the answer space blank.

CONTACT INFORMATION

We intend to follow up this part of the survey by interviewing a selection of users to obtain further information. If you have no objection to being interviewed, please fill in the details below.

NAME: .....

POSITION: .....

DEPARTMENT: .....

ROOM NUMBER (if applicable): .....

TELEPHONE (work/home): .....

STATUS (SVC) [ ][ ][ ]

(1) Which one of the following best describes your status as a user?

1. Academic staff member, teaching or research fellow (31%)
2. Postgraduate student (22%)
3. Undergraduate student (30%)
4. External user (13%)
5. Other (please specify) .....(4%)

[ ] 4

APPLICATION AND DEPENDENCY

(2) Which one of the following best describes your major use of the computer?

1. Examination and analysis of research data (37%)
2. Finding solutions to mathematical-type problems (32%)
   (e.g. modelling, simulation, dynamic programming)
3. Information processing (7%)
   (e.g. accounts and records, preparation of texts)
4. Studying computer technology and systems (19%)
   (e.g. Computer Science teaching and research)
5. Using the computer as a teaching tool (6%)
   (e.g. CAL)

[ ] 5

(3) In the context of your major use, which one of the following best describes the importance of the computer to your work?

1. The work would be impossible to undertake otherwise (28%)
2. The work would be otherwise limited in scope (25%)
3. Use of the computer saves time and effort (19%)
4. The computer itself is an inherent part of the study (29%)

[ ] 6

(4) Name the field of work for which you use the computer (e.g. Social Science, medicine, agriculture)

.....

(Commerce 8%; Computing 28%;
Engineering 20%; Natural Sciences 21%;
Physical Sciences 10%; Social Sciences 13%)

[ ][ ] 7

EXPERIENCE

(5) In what year did you first use a computer? 19 [ ][ ] 9
(Median: 1975)

(6) Please indicate your age at last birthday. [ ][ ] 11
(Mean: 29 years)

(7) How long a total period of instruction in computing have you received?

1. None (5%)
2. Less than one week (11%)
3. One week - one month (19%)
4. One month - six months (23%)
5. Six months - one year (13%)
6. Over one year (29%) [ ] 13

(8) Where did you receive the bulk of your instruction (if any) in computing?

1. Not applicable (4%)
2. Self-taught instruction course (e.g. Programmed instruction courses) (14%)
3. Computer Centre course at Canterbury (6%)
4. University course at Canterbury (43%)
5. Courses at other universities (and academic institutions) (25%)
6. Other (please specify) ..... (9%) [ ] 14

(9) What is the highest level of mathematics that you have studied? Choose the response that matches or is closest to that level.

1. School Certificate (5%)
2. University Entrance (14%)
3. Undergraduate level (69%)
4. Postgraduate level (13%) [ ] 15

(10) How adequate do you feel your mathematical knowledge is for the computing that you do?

Inadequate	Poor	Workable	Good	More than sufficient
1 (2%)	2 (5%)	3 (30%)	4 (29%)	5 (34%)

[ ] 16

CONTACT

(11) Do you instruct student classes in the use of computers, or act as a supervisor or consultant for classes?

YES 1 (28%) NO 5 (72%) [ ] 17

(12) Do you supervise individual research students or workers who use the computer?

1 (29%) 5 (71%) [ ] 18

(13) Do you have a departmental computer-related position, either official (e.g. consultant, liaison officer) or unofficial (e.g. local expert, charge of dept. software)?

1 (27%) 5 (73%) [ ] 19

(14) If you have ever used computing facilities other than those provided by the Computer Centre, please specify these, otherwise write 'Nil'.

.....

(Department 22%; Other 37%; Nil 41%)

[ ] 20

(15) What is your average gross expenditure on computing per month (in dollars)? (Mean: $31)

[| | |] 21

(16) On average how often do you use the computer?

Never	1 (2%)	Monthly	4 (17%)
Yearly	2 (8%)	Weekly	5 (37%)
Quarterly	3 (14%)	Daily	6 (22%)

[ ] 24

(17) How would you summarise the distribution of your computing activity over a year?

Very Irregular	Irregular	Sporadic	Regular	Continual
1 (13%)	2 (16%)	3 (36%)	4 (23%)	5 (11%)

[ ] 25

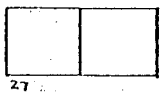
(18) At most, how long is it between the occasions on which you use the computer?

1 day	1 week	1 month	Several months	A year or more
1 (6%)	2 (21%)	3 (30%)	4 (34%)	5 (9%)

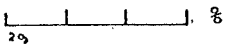
[ ] 26

MODE AND LANGUAGE SKILLS

(19.1) Name the language or package that you work with most: .....



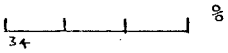
(19.2) Indicate the percentage of your work done with this language.



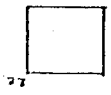
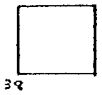
If you use other languages or packages, answer question (20). Otherwise leave blank.

(20.1) Name the other language or package that you work with most: .....

(20.2) Indicate the percentage of your work done with this language.



(21) How do you rate your knowledge of:

	Nil	Poor	Workable	Good	Fluent	
(21.1) - the language or package that you work with most	1 (2%)	2 (6%)	3 (45%)	4 (31%)	5 (16%)	
(21.2) - Burroughs Work Flow Language (job control language)	1 (18%)	2 (32%)	3 (37%)	4 (8%)	5 (5%)	
(21.3) - Burroughs CANDE (interactive system)	1 (39%)	2 (27%)	3 (19%)	4 (8%)	5 (7%)	

If your use of the computer involves developing programs (as opposed to providing data for packages), answer questions (22) and (23). Otherwise, please leave blank.

(22) How do you write your programs?

1.	In collaboration with others	(14%)
2.	By yourself	(62%)
(	Don't write programs)	(24%)

(23) Once your typical program is developed, will it:

1. Be used repeatedly with different parameters and/or data? (29%)
2. Be run again after modification or incorporation with other programs? (10%)
3. Have provided the end solution to the problem and will not be run again? (35%)
(Don't write programs) (26%)


41

MEDIUM

(24) There is a choice between use of the batch and CANDE services. Indicate the percentage of your computing effort spent on batch work. (If you use neither batch nor CANDE please leave the answer space blank). ___ %
42
(Batch only 45%; both media 43%; CANDE only 4%; blank 8%)

(25) Through which medium do you usually submit batch jobs?

1. Local batch at the Computer Centre (50%)
2. Remote batch at the Engineering School (21%)
3. Remote batch at Lincoln College (11%)
4. Department courier (12%)
5. Not a batch user (7%)


45

(26) How do you usually prepare your programs and data for input to the computer?

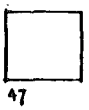
1. Use the professional data preparation service at the Computer Centre (51%)
2. Use professional data preparation service at Lincoln College (8%)
3. Do your own key punching (35%)
4. Explain your needs to someone else. (6%)


46

SUPPORT

(27) Roughly speaking, how often do you consult a Duty Programmer or programmer/analyst staff?

Never	Yearly	Quarterly	Monthly	Weekly or more often
1(26%)	2 (22%)	3(25%)	4(20%)	5 (8%)


47

(28) Do you have a copy of the Users' Guide? Yes 1 (54%) No 5 (46%) [ ] 48

(29) Do you receive copies of the User Notes? Yes 1 (40%) No 5 (60%) [ ] 49

(30) Do you receive regular copies of the Newsletter? Yes 1 (44%) No 5 (56%) [ ] 50

(31) How often do you consult documentation?

Never	Infrequently	Occasionally	Often	All the time
1 (12%)	2 (25%)	3 (33%)	4 (28%)	5 (3%)

[ ] 51

(32) How many Users' Group meetings do you attend per year? (None 83%; One 6%; Two 4%; Three 7%) [ ] 52

SATISFACTION

Please rate your satisfaction with topics considered in the next section according to the scale:

1. Highly dissatisfied
2. Dissatisfied
3. Indifferent - neither satisfied nor dissatisfied
4. Satisfied
5. Highly satisfied

If you have particular comments about any of the questions in this section, please write them on the last page of the questionnaire.

	Highly dissatisfied	Dissatisfied	Indifferent	Satisfied	Highly satisfied	
BATCH						
(33) If you use the batch service, please indicate how satisfied you are with:						
33.1 Turnaround time	1 (10%)	2 (33%)	3 (20%)	4 (33%)	5 (4%)	53
33.2 Hours of availability of batch facilities	1 (6%)	2 (14%)	3 (17%)	4 (53%)	5(10%)	54
33.3 Job submission and collection procedures	1 (8%)	2 (10%)	3 (25%)	4 (48%)	5(9%)	55
33.4 Present queue and priority structure	1 (2%)	2 (9%)	3 (31%)	4 (51%)	5(8%)	56
33.5 Location of batch facilities	1 (1%)	2 (8%)	3 (24%)	4 (50%)	5(18%)	57
33.6 Range of facilities available	1 (3%)	2 (9%)	3 (32%)	4 (47%)	5(10%)	58
CANDE						
(34) If you use the CANDE service, please indicate how satisfied you are with:						
34.1 Response time for editing	1 (4%)	2 (28%)	3 (20%)	4 (42%)	5(6%)	59
34.2 Response time for execution of tasks	1 (5%)	2 (31%)	3 (25%)	4 (33%)	5(6%)	60
34.3 Access available to CANDE services	1 (13%)	2 (36%)	3 (28%)	4 (18%)	5(6%)	61
34.4 CANDE task resource limits (e.g. processtime 30 secs)	1 (8%)	2 (25%)	3 (33%)	4 (28%)	5(6%)	62
34.5 Ease of obtaining assistance during a session	1 (8%)	2 (29%)	3 (48%)	4 (14%)	5(1%)	63
34.6 Range of facilities available	1 (4%)	2 (14%)	3 (37%)	4 (39%)	5 (5%)	64

GENERAL

		Highly dissatisfied	Dissatisfied	Indifferent	Satisfied	Highly satisfied	
(35)	How satisfied are you with:						
35.1	Quality of data preparation service	1 (1%)	2 (3%)	3 (21%)	4 (50%)	5 (25%)	65
35.2	Adequacy of computing funds to support your projects	1 (5%)	2 (12%)	3 (12%)	4 (47%)	5 (24%)	66
35.3	Response of Computer Centre to problems or suggestions that you have	1 (1%)	2 (5%)	3 (44%)	4 (37%)	5 (12%)	67
35.4	Quality of available documentation	1 (7%)	2 (17%)	3 (31%)	4 (40%)	5 (5%)	68
35.5	Willingness of Computer Centre to make provision for an unusual requirement	1 (1%)	2 (6%)	3 (44%)	4 (34%)	5 (16%)	69
35.6	Advice on system availability, breakdowns and delays	1 (4%)	2 (18%)	3 (32%)	4 (38%)	5 (8%)	70
35.7	Adequacy of Duty Programmer service	1 (1%)	2 (5%)	3 (40%)	4 (41%)	5 (12%)	71
35.8	Availability of Computer Centre staff	1 (2%)	2 (8%)	3 (36%)	4 (39%)	5 (14%)	72
35.9	Job/session diagnostics and error messages	1 (2%)	2 (12%)	3 (28%)	4 (51%)	5 (8%)	73
35.10	The Users Group as a medium of communication your needs	1 (1%)	2 (11%)	3 (71%)	4 (17%)	5 (0%)	74

75 80

GENERAL ASSESSMENT

(36) If you wish to clarify or expand upon any of your answers, please do so here.

Comments regarding the services provided are summarised below:

Batch service

- the inadequacy of the batch service received by undergraduate students required to use departmental courier services
- poor turnaround
- operator delays in handling input and output

CANDE service

- restricted hours and availability of terminals
- poor response

General services

- poor documentation; in particular concerning Work Flow Language and file handling
- lack of Centre expertise in statistical packages

(37) We will be pleased to receive below any comments you may wish to make about aspects of the service not covered by the questionnaire (graphics facilities, software packages, etc.).

The main points are listed below:

- inadequacy of Calcomp plotter and other graphics facilities
- the lack of card punch machines in the Engineering terminal room
- the general availability and reliability of the system
- file backup facilities and magnetic tape safeguards
- sharing the resource between undergraduate students and other users; between batch and interactive services.

Department of Computer Science
University of Canterbury Christchurch 1 New Zealand

ASSESSMENT OF THE EFFECTIVENESS OF

UNIVERSITY COMPUTING SERVICES

We would like to remind you of the questionnaire that was sent to you earlier this month. If you have not already done so, please complete it and return it as soon as you can.

Questionnaire returns may be posted to the above address, or handed to office staff in either the Computer Centre or the Computer Science Department. University users can make use of the internal mail service.

If you have any queries, do not hesitate to contact John Good (phone 488-237 (Computer Centre), ext. 85). Your co-operation is greatly appreciated.

John Good

23 July 1980 Chris Power

APPENDIX C

A DESCRIPTION OF THE COMPUTING SERVICES UNDER STUDY

The computing services under study were those provided on the Burroughs system or for its users by the University of Canterbury Computer Centre. Specifically excluded were the undergraduate computing facility, the Registry terminal (which was used solely by the central administration), services provided by the Lincoln College Computer Centre, and those computing services provided by University departments for their own use. In the description which follows, the model discussed in Section 3.1.1 has been used. The sources of information for this description are many; however, the aid of the User Note series, edited by Ms. N. Sutherland of the Computer Centre, is acknowledged.

(a) Site and equipment. The central computer was a Burroughs B6700 system which was installed in the Computer Centre in 1973. This system has been variously augmented over subsequent years, and in 1980 it was configured as follows:

224K memory, 40-bit words.

Input/Output processor, handling 50Mbyte fixed-head disk, 9-track magnetic tape cluster with 4 drives, 384 Mbyte disk pack storage on line, dual operator consoles, and local 1400 cpm reader and 1100 1pm line printer.

Data Communications Processor, connecting three RJE stations, a graphics system, and a PDP11/10 handling slow I/O devices and supporting twelve terminals.

Slow devices included a paper tape reader and punch, a 300cpm marksense/punched card reader, an on-line card punch, a Diablo high quality printer, and a Calcomp plotter. The graphics system comprised a PDP11/40, with 24K memory and floating point hardware, two disk drives, a hard-copy

terminal and display screen with light pen. The three RJE stations were sited at Lincoln College, in the Registry, and in the Engineering School. The Lincoln terminal comprised a PDP11/40, disks, operator console, card reader, line printers, paper tape reader and plotter. The Engineering terminal comprised a PDP11/10, console, card reader, line printer and a Statos printer/plotter.

The submission of batch jobs and the distribution of print-out at the Centre was handled by operations staff; at Lincoln this was done by Lincoln College Computer Centre staff. Users of the Engineering batch terminal had direct access to the card reader, the line printer and plotter.

Remote terminals were situated as follows: two VDU's in the James Hight Library building; two VDU's adjacent to the batch terminal in the Engineering School; two VDU's and slave printer controlled by a PDP11/20 in the Geography building; two hard-copy terminals in the Physics-Chemistry building; two hard-copy terminals in the Mathematics building; two VDU's in the Computer Centre for use by Centre staff.

User areas in the Computer Centre held card punches, an enquiry terminal, bench space and documentation. Batch jobs were submitted at a reception area and output was collected from boxes nearby.

(b) Software. The operating system used on the B6718 was Burroughs MCP version 3.0 (which replaced the previous version in May, 1979). Batch job control was provided by Burroughs Work Flow Language (WFL). Interactive users employed Burroughs Command And Edit message control system (CANDE).

Burroughs language compilers provided were: ALGOL, BASIC, COBOL, FORTRAN, PASCAL AND PL/1. A large number of packages written and adapted for use on the B6718 were available. These were statistical packages (notably SPSS, TEDDYBEAR, BMD, BASIS and GENSTAT), packages for simulation (DYNAMO, GASP67, SIMULA and others) and optimization (such as TEMPO and

MODELLER), program libraries (notably NUMERALS and 360SP), word processing packages (FMT and RUNOFF), and computer-assisted learning systems (STAF and MENTOR). In addition, there was a large quantity of user-written software; the commitment of University users to Burroughs extended ALGOL was estimated as 80,000 person-hours invested in software development.

(c) User Support. The following informational services were available: a consultative service, a monthly newsletter, assorted documentation, a library, service courses and noticeboards. The consultative or "duty programmer" service was provided by rostered Computer Centre programmer/analyst staff. Documentation comprised Burroughs and other reference manuals, on-line documentation and a Users' Guide. Following the appointment of a documentation editor in 1979, a series of User Notes was begun to supercede the Users' Guide. Service courses were usually short seminar courses held during University holidays.

User-Centre communication was facilitated by the following formal means: a Users' Group of which all main-account users (in general senior students and above) and Computer Centre staff were considered members, an Instructional Computing Group, liaison officers in all user departments, and a suggestion book.

Clerical staff provided miscellaneous support services at a reception counter in the Centre. They handled project registration, bookings for terminals, supplies and publications. Considerable technical support was provided by Computer Centre programmer.analyst, engineering and other technical staff, although not exclusively for the B6718 system. Operations staff handled all input and output at the central site (cards, print-out, magnetic tapes, etc.), controlled the job mix and resource usage, answered user queries and performed various other functions. A full data preparation service was also provided by the Centre.

(d) Allocation and administration. Access to the Burroughs system was available to batch users from 8.30 a.m. to 7 p.m. on weekdays, although operations typically continued until 11 p.m. or later. Hours for CANDE were increased from 1 - 5 p.m. to 9.30 - 10.30 a.m. and 1 - 6 p.m. in October, 1979.

A real-money marginal rate charging system has been used at Canterbury for many years. Funds allocated to user departments are not tagged for computing use but are intended to cover all research expenditure. (Further description can be found in an argument in support of this system by Good, 1980). Charges were levied on the use of the central and I/O processors ($30 and $10 per hour, respectively), memory ($0.00035 per kiloword-second) and all I/O operations, magnetic media storage, and consumable resources. Terminal hire and use of the graphics system were also chared ($1 and $5 per hour, respectively). Charging rates for external users were those described above multiplied by a factor of 2 or 6 depending on the nature of the work.

Batch jobs could be submitted in any one of four queues. Resource usage limits could be set by the user, but were ultimately restricted by queue resource limits. For example, the limits on processor time were 20, 120, 300 and 2,400 seconds, respectively for queues 1, 2, 6 and 10. Resource limits equivalent to those of a queue 2 batch job were applicable to tasks initiated interactively via CANDE. In July of 1978, a differential charging scheme was introduced which allowed users placing jobs in queues 2 and 6 an option of claiming a higher priority in those queues. High priority jobs were surcharged by 25%, while the cost of other jobs in those queues was discounted 25%.

The administration of the Computer Centre was headed by a director, who had *ex officio* seats on the Professorial Board and its Computer Facilities Committee. (The chairman of the Users' Group was also a member of this committee *ex officio*. The committee was charged with

formulation of policy for, and the coordination of, the development of computing facilities and services throughout the University. The committee was required to submit to the University Council proposals for allocation of funds to the Computer Centre for staff, running costs and equipment.

Major funding for re-equipment has been customarily dealt with on a quinquennial basis by the University Grants Committee. Accordingly, working parties of the Computer Centre produced rolling 5 year long-term plans for computing in the University in 1978 (Moon, *et al.*), 1979, and 1981 (Good and Brown).

APPENDIX D

FACTOR PATTERN MATRICES FOR THE EFFECTIVENESS MEASURES

NOTE: Tables are shown for the four sets of effectiveness measures: the batch and CANDE analyses from the 1978 and 1980 surveys. Each table contains the rotated factor pattern matrix, communalities of the variables, and eigenvalues for the rotated factors.

Table 36

Factor Pattern Matrix, 1978 Batch Analysis

QUESTION NUMBER AND SATISFACTION TOPIC	BATCH FACTORS, 1978 ONE	TWO	THREE	FOUR	COMMUNALITY
BATCH QUESTIONS					
A21.1 Turnaround time	.20	.56	.17	.07	.38
A21.2 Hours of availability	.09	.68	.04	.13	.49
A21.3 Queue and priority structure	.25	.43	.43	-.17	.46
A21.4 Advice of delays	.36	.45	.12	-.01	.34
A21.5 Location of facilities	.22	.43	.15	05	.26
GENERAL QUESTIONS					
A23 Centre response to problems	.69	.29	.27	-.04	.63
A24 Duty programmer service	.63	.31	.14	-.02	.51
A25 Availability of staff	.60	.39	-.03	.20	.55
A26 Data Preparation facilities	.42	.16	.02	.20	.24
A27 Quality of documentation	.32	.29	.23	.02	.24
A28 Provision for unusual requirements	.63	.02	.13	.21	.46
A29 Users' Group	.39	.23	.26	.11	.28
A30 Adequacy of funds	.19	.10	.14	.68	.53
A31 Fairness of charging algorithm	.14	.17	.84	.27	.82
EIGENVALUE	2.39	1.88	1.20	0.73	6.20

Table 37

Factor Pattern Matrix, 1978 CANDE Analysis

QUESTION NUMBER AND SATISFACTION TOPIC	CANDE FACTORS, 1978 ONE	TWO	THREE	FOUR	FIVE	COMMUNALITY
CANDE QUESTIONS						
A22.1 Editing response time	-.08	.11	.44	.28	.32	.39
A22.2 Task execution time	.13	.26	.73	-.16	.14	.66
A22.3 Hours of availability	-.11	.61	.14	.02	.18	.44
A22.4 Range of facilities	.01	.65	.28	.29	.14	.60
A22.5 Assistance during sessions	.11	.08	.87	.17	.05	.81
GENERAL QUESTIONS						
A23 Centre response to problems	.43	.34	.25	.42	.44	.73
A24 Duty Programmer service	.43	.69	.04	.30	.13	.77
A25 Availability of staff	.66	.39	.03	.42	.00	.76
A26 Data Preparation facilities	.24	.20	.15	.00	.33	.23
A27 Quality of documentation	-.01	.31	.08	.88	.09	.88
A28 Provision for unusual requirements	.53	-.28	.00	.45	.38	.71
A29 Users' Group	.21	.29	.19	.04	.38	.31
A30 Adequacy of funds	.89	-.08	.12	-.17	-.03	.84
A31 Fairness of charging algorithm	-.07	.09	.04	.08	.58	.35
EIGENVALUE	2.02	1.93	1.74	1.67	1.12	8.48

Table 38

Factor Pattern Matrix, 1980 Batch Analysis

QUESTION NUMBER AND SATISFACTION TOPIC	BATCH FACTORS, 1980 ONE	TWO	THREE	FOUR	FIVE	COMMUNALITY
BATCH QUESTIONS						
B33.1 Turnaround time	.14	.47	.62	.10	.06	.63
B33.2 Hours of availability	.12	.27	.52	.00	.19	.39
B33.3 Job submission and collection procedures	.10	.87	.07	.18	.24	.87
B33.4 Queue and priority structure	.24	.19	.30	.29	.06	.27
B33.5 Location of facilities	.03	.17	.13	.13	.82	.73
B33.6 Range of facilities	.28	.04	.28	.36	.37	.43
GENERAL QUESTIONS						
B35.1 Data Preparation service	.45	.14	.15	-.22	.14	.31
B35.2 Adequacy of funds	.21	.44	.12	-.03	.03	.25
B35.3 Centre response to problems	.49	.13	.33	.18	.14	.42
B35.4 Quality of documentation	.15	.05	.26	.61	-.03	.47
B35.5 Provision for unusual requirements	.55	.34	.14	.19	-.04	.48
B35.6 System availability	.27	.20	.17	.17	-.05	.18
B35.7 Duty Programmer service	.56	.02	.11	.32	.10	.44
B35.8 Availability of staff	.76	.11	.06	.18	-.01	.63
B35.9 Diagnostics and messages	.10	.06	-.02	.49	.20	.30
B35.10 Users' Group	.12	-.05	.48	.12	.03	.27
EIGENVALUE	2.00	1.53	1.35	1.18	1.00	7.06

Table 39

Factor Pattern Matrix, 1980 CANDE Analysis

QUESTION NUMBER AND SATISFACTION TOPIC	CANDE FACTORS, 1980 ONE	TWO	THREE	FOUR	FIVE	SIX	COMMUNALITY
CANDE QUESTIONS							
B34.1 Editing response time	-.04	.74	.02	.00	.07	.07	.55
B34.2 Task execution time	-.06	.94	.12	.03	-.02	.03	.91
B34.3 Access to services	.06	.32	.18	.14	.51	.33	.53
B34.4 Task resource limits	.23	.28	-.17	.11	.19	.21	.26
B34.5 Assistance during sessions	.64	-.11	.08	.15	.18	.07	.49
B34.6 Range of facilities	.25	-.02	.19	.21	.70	-.19	.66
GENERAL QUESTIONS							
B35.1 Data Preparation service	.57	.12	.05	-.13	.23	.18	.45
B35.2 Adequacy of funds	.31	-.17	.20	.14	.17	.02	.21
B35.3 Centre response to problems	.16	.14	.68	.08	.09	.36	.66
B35.4 Quality of documentation	.18	.04	.02	.73	.09	.12	.59
B35.5 Provision for unusual requirements	.22	-.09	.61	.20	.06	-.05	.48
B35.6 System availability	.06	.08	.53	.04	.11	-.06	.31
B35.7 Duty Programmer service	.46	.01	.37	.33	-.02	.03	.47
B35.8 Availability of staff	.78	.03	.47	.01	-.29	-.15	.94
B35.9 Diagnostics and messages	-.04	.02	.18	.46	.10	.06	.26
B35.10 Users' Group	.07	.06	.01	.12	-.03	.63	.42
EIGENVALUE	1.89	1.71	1.67	1.05	1.04	0.81	8.16